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REVISION OF NORTH AMERICAN SPECIES OF GODETIA

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(WITH ONE FIGURE)

Introduction

This study, which has been carried on at the Herbarium of Pomona College, was undertaken at the suggestion of Dr. PHILIP A. MUNZ. He had collected important notes on the genus *Godetia* while at the Gray Herbarium, and I am deeply indebted to him for the use of these notes, as well as for his guidance in the preparation of this paper.

In the summer of 1928 the herbarium of the California Academy of Sciences was visited, with access to valuable notes on the genus by Miss ALICE EASTWOOD, to whom gratitude is hereby expressed. I wish also to thank Dr. W. A. SETCHELL of the University of California for the loan of the important memoranda on *Godetia* left by the late Mrs. KATHARINE BRANDEGEE, whose knowledge of the group cannot be questioned. I am indebted also to several others who have either furnished color notes, or looked up references. They are Mr. T. A. SPRAGUE of the Royal Botanic Garden at Kew, Mr. DAVID KECK of the Carnegie Institute, Dr. AVEN NELSON of the University of Wyoming, Professor P. B. KENNEDY of the University of California, and Mr. THOMAS CRAIG of Pomona College.

For carrying on this revision, material has been available from the following sources: Pomona College Herbarium (P), Herbarium of the University of California (C), Gray Herbarium of Harvard Uni-

versity (G), Dudley Herbarium of Stanford University (S), Herbarium of the Santa Barbara Museum (SB), private herbarium of Dr. JEPSON (Jep). To the curators of these herbaria, and particularly to Dr. W. L. JEPSON, who very kindly lent his types, I wish to express appreciation. The abbreviations indicated for the different herbaria are those used in this paper when citing specimens.

History of genus

The first species of *Godetia* was published by CURTIS, Bot. Mag. **10**: pl. 352. 1796, as *Oenothera purpurea;* it was described from material grown in the Royal Garden at Kew, from seeds collected on the western coast of North America. The next two species published, *Oe. tenella* Cav. Ic. **4**:66, pl. 396. 1797, and *Oe. tenuifolia* Cav. *loc. cit.* 67, pl. 397, were South American. After these followed *Oe. romanzowii* Ledeb. *ex* Hornem., Hort. Hafn. Suppl., 133. 1819; *Oe. amoena* Lehmann, Ind. Sem. Hort. Hamb. 8. 1821; *Oe. roseo-alba* Bernh., Ind. Sem. Hort. Erford (1824); *ex* Reichb. Ic. Bot. Exot. **1**:34, pl. 47. 1827; *Oe. quadrivulnera* Douglas *in* Lindl., Bot. Reg. **13**: pl. 1119. 1828; *Oe. viminea* Dougl. *ex* Hooker *in* Bot. Mag. *et Oe. lindleyi* Dougl. *in* Bot. Mag. **55**: pl. 2832. 1828; *loc. cit.* pl. 2873; and *Oe. decumbens* Dougl. *in* Bot. Mag. **56**: pl. 2889. 1829. Five of these species were treated by SERINGE *in* DC. Prodr. **3**:48–49. 1828.

Godetia was proposed as a genus in 1835 by SPACH, Hist. Nat. Veg. Phan. **4**:386–392. 1835, being named for Mr. CHARLES GODET, a Swiss botanist; here eight species were recognized. That same year SPACH published a more scientific treatment, Nouv. Ann. Mus. Par. III, **4**:387–394. 1835, where he recognized eleven species; eight of them, *G. willdenowiana, G. decumbens, G. viminea, G. quadrivulnera, G. romanzowii, G. lehmanniana, G. lindleyana,* and *G. bottae* from North America; the other three, *G. tenuifolia, G. gayana,* and *G. cavanillesii* (*tenella*) from South America. HOOKER, Fl. Bor. Am. **1**:209–213. 1840, and TORREY and GRAY, Fl. N. Am. **1**:502–505. 1840, did not recognize *Godetia* as a genus. The last attempt to include both North and South American species in one treatment was by WALPERS, Repertorium **2**:87–89. 1843, where *Godetia* was made to include seventeen species.

In the following references, only North American species have

been considered. WATSON, Proc. Am. Acad. **8**:596–600. 1873, followed TORREY and GRAY in treating *Godetia* as a section under *Oenothera;* he recognized fourteen species: *G. grandiflora*, *G. purpurea*, *G. lepida*, *G. albescens*, *G. williamsonii*, *G. quadrivulnera*, *G. tenella*, *G. viminea*, *G. romanzowii*, *G. amoena*, *G. bottae*, *G. epilobioides*, *G. hispidula*, and *G. biloba;* but later, Bot. Cal. **1**:228–231. 1876, he recognized *Godetia* as a genus. The only modern revision of the group was by JEPSON, Univ. Cal. Pub. Bot. **2**:319–354. 1907, who had seventeen species and many varieties. LEVEILLE included the group in his monograph in 1908, using four species and eleven varieties. NELSON and MACBRIDE, BOT. GAZ. **65**:59–65. 1918, transferred the genus to *Clarkia*, scarcely changing JEPSON'S concept of species and varieties. In addition to these more inclusive references, many others could be cited where single species have been proposed. Altogether about fifty species have been described, eight of which were South American. For North America I am recognizing twelve species and eleven varieties.

Generic status and relationship

NELSON and MACBRIDE, BOT. GAZ. **65**:59–60. 1918, called attention to the fact that *Godetia* and *Clarkia* are perhaps too closely related to be kept as distinct genera. In order to describe the generic status of *Godetia* more authoritatively, Dr. P. A. MUNZ and I have collaborated in a study of the species commonly included in *Clarkia* and *Eucharidium*. It has been decided to keep *Godetia* as a separate genus (Bull. Torr. Club **56**:181. 1929).

Because of lack of space, relationships within the genus are not discussed, other than those indicated in fig. 1.

Godetia Spach

GODETIA AS A GENUS: Spach Hist. Nat. Veg. Phan. **4**:386. 1835, Nouv. Ann. Mus. Par. III, **4**:387. 1835; Walp. Rep. **2**:87. 1843; Greene Fl. Fran. 219. 1891; Raimann *in* Engl. and Prantl Nat. Pflfam. **3**, Ab. 7:213. 1898; Jepson, Univ. Cal. Pub. Bot. **2**:324. 1907; Piper and Beattie Fl. N. W. Coast 250. 1915; Jepson Man. Fl. Pl. Cal. 674. 1925.

GODETIA AS A SECTION: T. and G. Fl. N. Am. 1:502. 1840; Watson, Proc. Am. Acad. 8:596. 1873; Leveille Monog. Onoth. 260. 1908.

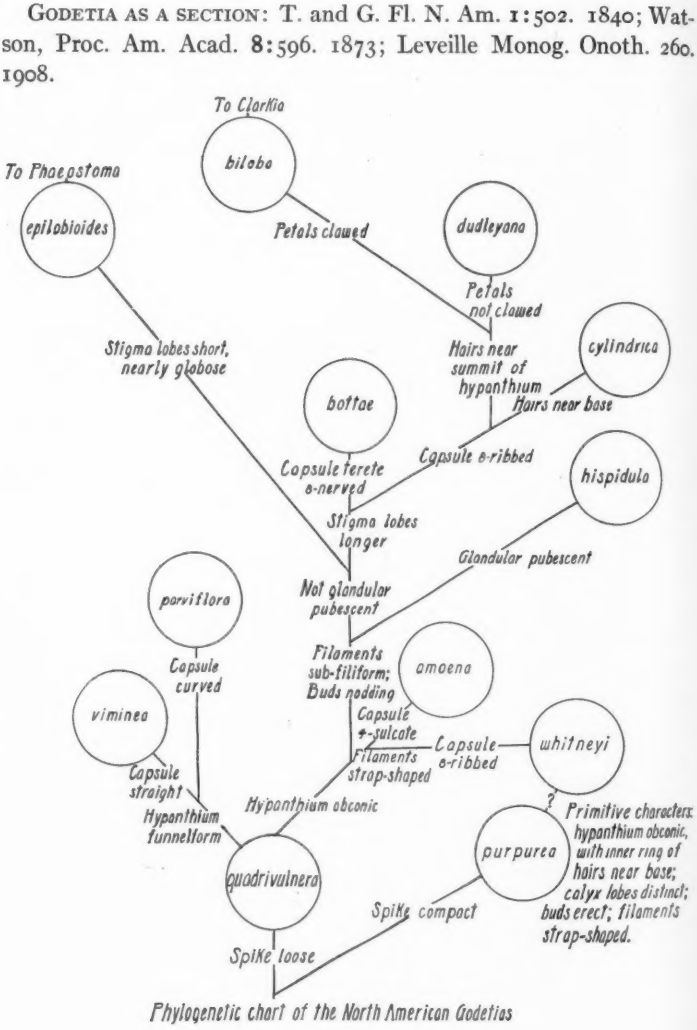

FIG. 1

GODETIA INCLUDED IN CLARKIA: Nels. and Macbr., BOT. GAZ. 65:59. 1918.

Calyx tube obconic to narrowly funnelform, with inner ring of hair. Calyx lobes distinct and reflexed, or partially or wholly united and turned to one side. Stamens in two series, those opposite petals shorter; filaments filiform to flattened; anthers subequal to equal, usually wholly fertile, but tips sometimes sterile, sparsely hairy. Stigma lobes short, ovoid to linear, yellow to purple. Capsules 4-sulcate, terete and 8-nerved, or heavily 8-ribbed, linear to ovoid, sessile to long pedicelled, beakless to long beaked. Seeds brown, sometimes somewhat cellular-puberulent, upper margin fimbriate. Flowers white to purple; petals cuneate to obovate, apex entire, erose, retuse or bilobed, clawless or with claw as much as 2 mm. long. Buds nodding or erect. Inflorescence a spike or small panicle, usually loose, but sometimes much shortened. Leaves linear to spatulate, lower ones commonly deciduous, reduced in size up the stem, born in fascicles, the secondary ones much reduced in size, usually remotely denticulate, sometimes entire. Epidermis of stems exfoliating below. Annuals.

Type species: *G. purpurea.*

The type species is rather difficult to determine by ordinary criteria. From SPACH'S description apparently he had no particular species in mind when proposing the genus; however, *G. purpurea* (*G. willdenowiana*) is the first species listed by him and, furthermore, is the first of the species now included in *Godetia* which was made known to science.

Key to species

A. Hypanthium with inner ring of hairs one-fourth to three-fifths way from base to summit; buds erect except in nos. 3, 7, and 8.
  B. Stigma lobes 4–7 mm. long.
    C. Capsule greatly enlarged at middle; petals 4–6 cm. long. Shelter Cove, Humboldt Co., California....4. *G. whitneyi*
    C. Capsule not greatly enlarged at middle; petals not over 4 cm. long. Watsonville, California, to British Columbia
      3. *G. amoena*
  B. Stigma lobes less than 4 mm. long.
    C. Capsule 4-sulcate when immature, terete and 8-nerved when dried.....3. *G. amoena*

C. Capsule 8-ribbed when immature, terete or somewhat quadrilateral and 8-nerved when dried.

D. Buds nodding; calyx lobes united in anthesis.

E. Capsules elongate, linear, frequently quadrilateral and smooth in mature specimens; petals lavender, usually with purple base; stigma lobes oval; inflorescence never glandular-pubescent. Plants of inner Coast Ranges, from Los Angeles Co. to Fresno Co., California
8. *G. cylindrica*

E. Capsule not linear, ribs evident in dried material; petals lavender without purple base; stigma lobes linear; inflorescence frequently glandular-pubescent. Plants of Sierran foothills from Mariposa Co. to Butte Co., California.....7. *G. hispidula*

D. Buds erect; calyx lobes usually distinct, but sometimes united, especially in no. 6 and one variety of no. 1.

E. Hypanthium 5–15 mm. long, slender toward base, flaring at top; ovary usually with annular swelling at summit.

F. Plants branching from base, somewhat ascending; branchlets filiform; capsule usually quite strongly curved. Coastal plants from San Luis Obispo Co. to Santa Cruz Co., California.....6. *G. parviflora*

F. Plants branching mainly from middle, erect; branchlets stout; capsule straight, or nearly so. Plants chiefly from Sierras and region about San Francisco Bay
5. *G. viminea*

E. Hypanthium 2–7 mm. long, tapered uniformly from base to summit; without annular swelling at top of ovary.

F. Inflorescence congested in normal plants; capsule enlarged at middle; leaves 3–18 mm. wide. Plants usually found at edge of lakes or drying pools
2. *G. purpurea*

F. Inflorescence not congested in normal plants; capsules not enlarged at center; leaves 2–8 mm. wide. Plants usually found in rather dry or well-drained soil.....1. *G. quadrivulnera*

A. Hypanthium with inner ring of hairs at least three-fifths of way from base to summit; buds nodding.

B. Petals less than 1.5 cm. long, white or cream, sometimes tinged with pink; stigma lobes very short, not over 0.5 mm. long. Chiefly Southern California.....11. *G. epilobioides*

B. Petals 1.5 cm. or more long, lavender to purple; stigma lobes more than 0.5 mm. long.

C. Capsule narrowly linear, 2–4 cm. long, 0.1–0.2 cm. thick; petals lavender with purple base. Along inner Coast Ranges from Los Angeles Co. to Fresno Co., California
8. *G. cylindrica*

C. Capsule thicker; petals lavender but without purple base.

D. Filaments unequal, slightly flattened; capsule terete and very faintly nerved in living material, quadrilateral and obscurely nerved or smooth when mature, especially in herbarium material; pedicels as much as 2 cm. long. Near coast from Orange Co. to Monterey Co., California
9. *G. bottae*

D. Filaments subequal, subfiliform; capsule 8-ribbed in living material, ribs very evident when mature or dried; pedicel usually less than 3 mm. long.

E. Petals bilobed; capsule short-pedicelled. Sierra Nevadan foothills from Mariposa Co. to Nevada Co., and from Contra Costa Co., California.....12. *G. biloba*

E. Petals not bilobed; capsule sessile to nearly so. Mountains from San Jacinto Range northward through Sierras to Mariposa Co., California.....10. *G. dudleyana*

Treatment of species

1. GODETIA QUADRIVULNERA (Dougl.) Spach Hist. Veg. Phan. 4: 389. 1835.

Plants usually erect, sometimes ascending, branching from base or middle, stems 1–8 dm. tall; leaf blades lanceolate to spatulate, 1–5 cm. long, 0.2–0.8 cm. wide, acute to rounded, short petioled or sessile; buds erect; hypanthium 2–6 mm. long, brownish-green outside and within, inner ring of hairs about one-third way from base; calyx lobes green or yellow, 5–10 mm. long, usually distinct and well reflexed in anthesis, but sometimes united in pairs, or all united, the

tips not free in bud; petals varying from pale lavender, with or without spot of purple at apex or in center, to deep purple, 0.5–2 cm. long, 0.5–1.8 cm. wide, cuneate, the apex rounded to truncate and usually somewhat erose, not clawed; filaments unequal, 1–6 mm. long, the short ones one-third to one-half as long as others; anthers subequal, 2–4 mm. long, white to pale lavender; style varying in length from scarcely equal to short stamens to slightly longer than long ones; stigma lobes about 1 mm. long and as broad, lavender to purple; ovaries sparsely pubescent to densely white- or brown-hirsute, about equal to length of buds; capsules 1–3.5 cm. long, 2–3 mm. thick, not noticeably enlarged at center, sessile or with pedicels as much as 2 mm. long, tapering to beak 0.5–3 mm. long, terete and 8-ribbed with a faint nerve between ribs in fresh material, the capsules in dried specimens often square in cross-section, this squareness being accentuated on pressing, at which time nerves between the ribs are quite conspicuous; seeds 1 mm. long and broad, cresting about one-fifth as long as seed proper.

Key to varieties

A. Leaves short, 1–2 cm. long, oblong to spatulate, rounded; capsules scarcely beaked, ribs very prominent, especially along sutures. Coastal, from Monterey Co. to Humboldt Co., California.....1*a*. *G. quadrivulnera* var. *davyi*

A. Leaves longer, 2–5 cm. long, elliptic, acute; capsules blunt to long-beaked, ribs about equal in prominence.

B. Calyx lobes usually united; capsule very slender, with beak 2–4 mm. long. Chiefly from Santa Clara and Sacramento Valleys, California.....1*b*. *G. quadrivulnera* var. *vacensis*

B. Calyx lobes usually reflexed and distinct; capsule somewhat stout, beak usually not over 2 mm. long. Lower California to Washington.....1*c*. *G. quadrivulnera* var. *typica*

1*a*. GODETIA QUADRIVULNERA var. DAVYI Jepson, Univ. Cal. Pub. Bot. **2**:341. 1907.—*Oenothera tenella* Wats., Proc. Am. Acad. **8**:615. 1873, as to Monterey, *State Survey* 638, collection; *Godetia parviflora* Jepson, *loc. cit.* 339, as to Monterey, *State Survey* 638, coll.

Leaves oblong to spatulate, 1–2 cm. long, 0.3–0.6 cm. wide, rounded; calyx lobes reflexed in pairs or distinct; capsule 1–2.5 cm. long,

not beaked, finely and rather sparsely white-pubescent, ribs glabrous, brown, very prominent, especially at the sutures.

Type locality, Point Reyes, Marin Co., California.

Material examined, CALIFORNIA: Monterey, *Parry* (G), *Abbott* in 1904 (S), *Brewer* 638 (C), *Guirardo* 638 (G); Santa Cruz Co., Santa Cruz, *Jones* in 1881 (P); San Mateo Co., Ocean View, *Heller* 8382 (C,G,S), *Heller* 8384 (G,S), *Congdon* in 1889 (G), *Walker* 1142 (C); Marin Co., Pt. Reyes, *Davy* 6701, type collection (C), *Elmer* 4610 (C,P,S); Mt. Vision, *Hall* 8511 (C); Humboldt Co., Humboldt Bay, *Tracy* 2592 (C,G), *Tracy* 3127 and 3256 (C); Alton, *Tracy* 3771 and 3772 (C); Kneeland Prairie, *Tracy* 3030 (C); Del Norte Co., Lake Earl, *Parks* 8276 (C).

1*b*. GODETIA QUADRIVULNERA var. VACENSIS Jepson, Univ. Cal. Pub. Bot. **2**:341. 1907. Leaves lanceolate, 2–5 cm. long, 0.2–0.4 cm. wide, acute; calyx lobes usually united in anthesis; capsule 2–4 cm. long, very slender, beak 2–4 mm. long, ribs of equal prominence.

Type locality, Vaca M^ts., Napa or Solano Co., California.

Representative material, CALIFORNIA: Ventura Co., Ojai Valley, *Hall* 3192 (C); San Luis Obispo Co., Paso Robles, *Cobb* in 1907 (C); Monterey Co., Santa Lucia Mts., *Barber* in 1899 (C); 10 mi. N. of Bradley, *Mallory* in 1920 (S); Santa Cruz Co., below Big Trees, *Dudley* in 1893 (S); Santa Clara Co., Cupertino, *Heller* 8552 (G,S); Tuff Hill, *Cameron* in 1900 (S); Stanford University, *Atkinson* in 1900 (S); San Benito Co., Griswold Creek, *Abrams* and *Borthwick* 7944 (S); Hernandez, *Dudley* in 1899 (S); Eagle Creek, *Dudley* in 1899 (S); Contra Costa Co., Vallejo Junction, *Michener* and *Bioletti* 177 (G); Solano Co., near Vacaville, *Jepson* in 1891, probably typical material (S); Sacramento Co., Arbuckle, *King* in 1905 (C). The following are more or less intermediate between this variety and var. *typica:* Sierra Valley, Rattan (S); Shasta Co., Redding, *Heller* 7902, type collection of *G. rostrata* Eastw. Muhlenbergia **2**:103. 1905, *nomen nudum* (G); Yolo Co., Winters, *Heller* and *Brown* 5584 (G,S); Mt. Diablo, *Abrams* 5712 (S); Stanford University, *Faker* 843 (C,G,P,S); *Geol. Surv. Cal.* (G).

1*c*. GODETIA QUADRIVULNERA var. **typica,** nom. nov.—*Oenothera quadrivulnera* Dougl. *ex* Lindl., Bot. Reg. **13**:*t.* 1119. 1828; T. and G. Fl. N. Am. **1**:504. 1840; S. Wats., Proc. Am. Acad. **8**:598. 1873; *Godetia quadrivulnera* Spach, *loc. cit.;* Jepson, Univ. Cal. Pub. Bot. **2**:340. 1907; *Clarkia quadrivulnera* Nels. and Macbr., BOT. GAZ. **65**: 63. 1918; *Oe. quadrivulnera* var. *hirsuta* Kellogg, Proc. Cal. Acad. **5**: 45. 1873; Curran, Bull. Calif. Acad. **1**:137. 1885; *G. quadrivulnera* var. *tenella* Jepson Fl. W. Mid. Calif. 334. 1901; *G. quadrivulnera*

var. *apiculata* Jepson, Univ. Cal. Pub. Bot. **2**:341. 1907; *G. quadrivulnera* f. *flagellata* Jepson, *loc. cit.*; *G. quadrivulnera* var. *flagellata* Jepson Man. Fl. Pl. Cal., 678. 1925; *G. quadrivulnera* f. *setchelliana* Jepson, Univ. Cal. Pub. Bot. **2**:341. 1907; *G. quadrivulnera* var. *setchelliana* Jepson Man. Fl. Pl. Cal., 678. 1925; *G. quadrivulnera* var. *hallii* Jepson, Univ. Cal. Pub. Bot. **2**:341. 1907; *G. quadrivulnera* var. *rubrissima* Jepson, *loc. cit.* 342; *Oe. prismatica* var. *quadrivulnera* Leveille Monog. Onoth. 267. 1908; *Oe. viminea* var. *intermedia* Kellogg, Proc. Cal. Acad. **1**:61. 1854–57, Curran, Bull. Cal. Acad. **1**: 137. 1885; *Oe. tenella* Wats., Proc. Am. Acad. **8**:598. 1873, in part; *Oe. auricula* var. *tenella* Leveille Monog. Onoth. 270. 1908, in part; *Godetia bingensis* Suksd., Deutsch. Bot. Monat. **18**:88. 1900; G. *albescens* var. *micropetala* Jepson Fl. W. Mid. Cal. 334. 1901; *G. goddardii* Jepson, Univ. Cal. Pub. Bot. **2**:342. 1907; *G. goddardii* var. *miguelita* Jepson, *loc. cit.*; *G. sparsifolia* Jepson, *loc. cit.* 347.

Leaves oblong to lanceolate, 2–5 cm. long, 0.2–0.6 cm. wide, acute; calyx lobes usually distinct in anthesis; capsule varying, beak not usually over 2 mm. long, ribs of equal prominence.

Type locality, "North West of North America."

Representative material, WASHINGTON: Klickitat Co., Bingen, *Suksdorf* 86, isotype of *G. bingensis* (G,S); Clallam Co., Olympic Mts., *Elmer* 2567, isotype of *G. brevistyla* (S). OREGON: Josephine Co., W. fork of Illinois R., *Abrams* 8639 (P,S); Grant's Pass, *Prescott* in 1912 (G,S); Marion Co., Salem, *Nelson* 727, flowers unusually large, (S); Hood River Co., Lower Hood River, *Henderson* 835 in 1924 (G). CALIFORNIA: without locality, *Douglas*, probably type material (G); Howell Mt., *Jepson* 2441, type of *G. quadrivulnera* var. *apiculata* (Jep); Klamath Hills, *Butler* 1375 (C,P); Trinity Co., Rush Creek, *Yates* 405 (C); Humboldt Co., Redwood Forest, *Abrams* 6028 (S); Mendocino Co., Ukiah, *Munz* 9867 (P); Glenn Co., near Bennett Spring, *Heller* 11540 (C,G,S); Butte Co., Cohasset, *Heller* 11908 (G,S); Plumas Co., between Taylorville and Crescent Mills, *Heller* and *Kennedy* 8827 (C,G,S); El Dorado Co., New York Ravine, *Brandegee* in 1907 (C); Amador Co., Jackson, *C. L. Hitchcock* 30 (P); Pine Grove, *Hansen* 1157 (P,S); Calaveras Co., Copperopolis, *Davy* 1337 (C); Tuolumne Co., Bear Creek, *Mrs. Williamson* 58 (P,S); Sonoma Co., Petaluma, *Kellogg* in 1870, type material *G. quadrivulnera* var. *hirsuta* (G); Lake Co., near Lakeport, *Baker* 3060 (C,G,P); Napa Co., Vaca Mts., *Jepson*, June 12, 1893, type *G. quadrivulnera* f. *flagellata* (Jep, C); Contra Costa Co., Mt. Diablo, *Abrams* 8040 and 8048 (S); Alameda Co., Alameda, *Bolander* in 1866 (G,C), *Dr. Kellogg* in 1866, type material *G. viminea* var. *intermedia* (C); San Mateo Co., Big Basin, *Dudley* in 1897 (S); Santa Clara Co., near Stanford University,

Baker 5066 (C,P), 859 (G,P); Mt. Hamilton, *Elmer* 4825 (C,P,S); San Benito Co., Hernandez, *Lathrop* in 1903 (S); Santa Cruz Co., Santa Cruz Mts., *Jepson* 13335, type of *G. quadrivulnera* f. *setchelliana* (Jep); Monterey Co., near Del Monte, *Heller* 6834 (G,S); near seaside, *Heller* 6754, approaching var. *davyi* (C,G,P,S); San Miguelito Rancho, *Jepson* 1625, type *G. goddardii* var. *miguelita* (Jep); San Luis Obispo Co., San Luis Obispo, *Brewer* 477 (C,G); Cuesta Pass, *C. L. Hitchcock* 7 (P); Price Canyon, *C. L. Hitchcock* 3 (P); Atascadero, *Brewer* 508 (C); Santa Barbara Co., Knapp's Lodge, *Hoffman* in 1925 (SB); road to Montecito, *Eastwood* 151 (C,G); Ventura Co., Nordhoffe, *Hall* 3194 (C); Los Angeles Co., Saugus, *K. Brandegee* in 1909 (C); Claremont, *Baker* 5352 (P,S); Palmer's Canyon, near Claremont, *C. L. Hitchcock* 54 (P); Sepulveda Canyon, Santa Monica Mts., *Abrams* 304 (S); Santa Catalina Isl., *Dunkle* 1870 (P); San Bernardino Co., Potato Canyon, *Parish* 3222 (G,S); Mojave River, *Palmer* 141 (C), *Parish* 4987 (S); Arrowhead Springs, *Feudge* 1562 (P); Riverside Co., east base Box Springs Mts., *Hall* 6240, type collection *G. quadrivulnera* var. *rubrissima* (C,P), *Hall* 6241, type collection *G. quadrivulnera* var. *hallii* (C,P); San Jacinto Mt., *S. B.* and *W. F. Parish* 1501 (G,S); San Diego Co., San Diego, *Thurber* 533 (G), *Palmer* 104 (G); Jacumba, *Abrams* 3688 (G,S); Palomar Mts., *Munz* 8217 (P); Descanso, *K. Brandegee* in 1906 (C), *Munz* and *Harwood* 7172 (P). LOWER CALIFORNIA: North of Ensenada, *Canby* in 1925 (P).

Godetia quadrivulnera is the most widespread, as well as the most variable species of the genus. There seems to be no constancy in the coloration of petals; plants with flowers varying from pale lavender to purple, with or without spots, are often found growing together, all apparently from the same seed. Because of this fact I do not consider it wise to recognize such varieties as *hallii* and *rubrissima*, which are merely color variations. The pubescence of the inflorescence also shows extreme variation, many collections showing plants which have some capsules that are densely hirsute and others that are merely strigillose. Therefore, there is no reason for recognizing KELLOGG's variety *hirsuta*. Other collections with hirsute capsules are: Santa Lucia Mts., *K. Brandegee* in 1909 (C); San Luis Obispo, *Brewer* 477 (C,G).

No difference can be seen between the type material of *G. bingensis* and ordinary *G. quadrivulnera*. Likewise *G. brevistyla* is not recognized, since style length is a rather variable character in *Godetia*, and much of the material of *G. quadrivulnera* from California has just as short styles as has *G. brevistyla*. *G. goddardii* I consider to be a rather large-flowered form of *G. quadrivulnera;* the

spike is somewhat shortened, but not unusually so, and the capsules are certainly those of *G. quadrivulnera* (1.5 cm. long, 8-ribbed, puberulent, and not thickened at the middle). *G. goddardii* var. *miguelita* has rather short, thick capsules, but they are no more hairy than much of the material from the Monterey region. The flower is small, being undoubtedly that of *G. quadrivulnera*, and the inflorescence is a rather loose spike, with the capsules 1.5–5 cm. apart. *G. quadrivulnera* var. *flagellata* is not unusual. It is a tall plant with the capsules well scattered. I believe, however, that this condition is largely ecological; certainly the inflorescence of *G. quadrivulnera* becomes shortened where the plants grow in a dry, poor soil. *G. quadrivulnera* var. *setchelliana* is not different from ordinary material, so far as can be seen; in the type collection one of the plants shows basal branching, but two others, somewhat smaller, are unbranched, and the young ovaries of almost any collection are as canescent as those of this collection. The var. *apiculata* is a rather slender plant, with slender capsules and buds, the latter having an unusually long tip, but this does not warrant nomenclatural recognition.

G. quadrivulnera is very easily confused with *G. purpurea* and *G. viminea*. Where the former species grows in poor soil, or lacks sufficient moisture, the inflorescence tends to become shortened and the flowers crowded, consequently the material resembles *G. purpurea*. It was such a form from Tracy, San Joaquin Co., *Cobb* in 1900 (C), that JEPSON called *G. sparsifolia*. Other collections of this nature are: Calaveras Co., Copperopolis, *Davy* 1367 (C); San Diego Co., Lakeside, *Brandegee* in 1906 (C); El Dorado Co., Simpson's Ranch, Sweetwater Creek, *K. Brandegee* in 1908 (C); Scott River Valley, *Gilbert* in 1899 (C). In general, however, *G. purpurea* has wider leaves and a more inflated capsule than *G. quadrivulnera*. Some robust specimens of *G. quadrivulnera* have petals as large as those of *G. viminea*, examples being: Griffith Park, Los Angeles, *Braunton* 401 (C); San Bernardino Co., Cucamonga Canyon, *Williams* (C); Humboldt Co., Hupa Road near Redwood Creek, *Jepson* 1971, type of *G. goddardii* (Jep); Santa Ana River Canyon, *Munz, Street,* and *Williams* 2669 (P,S); Marin Co., hills above Fairfax, *K. Brandegee* (C). The only methods of distinguishing such plants from *G. viminea*

are by the stigma lobes, which are 1 mm. long in *G. quadrivulnera* and 1.5 mm. or more in *G. viminea*, and by the capsules, *G. quadrivulnera* having the larger.

The fact that the capsules often appear square in cross-section when pressed and dried has led to some confusion as to ribbing. All capsules are terete and 8-ribbed when growing. The plant from "road to Napa Soda Springs," *Jepson* in 1893 (C), which JEPSON called *G. albescens* var. *micropetala* in his flora of Western Middle California, and *G. goddardii* in his revision, appears to be a rather average plant of *G. quadrivulnera* with large capsules, which have not been flattened by pressing.

In studying some 500 sheets of material of this species, I was impressed with the extreme variation in nearly all characters, and firmly believe that it is inadvisable to try to split the group into numerous ill defined segregates.

2. GODETIA PURPUREA (Curt.) G. Don *in* Sweet Hort. Brit., ed. III, 237. 1839.

Erect, simple, or with branches and branchlets closely crowded at summit so that a very compact inflorescence is generally formed, the flowers and capsules usually being partially concealed by the leaves; stems 1–6.5 dm. tall, finely pubescent to almost glabrous; leaves 1.5–4 cm. long, 0.3–1.8 cm. wide, lanceolate to broadly elliptic, obtuse to acuminate, short petioled; buds erect, 0.6–1.5 cm. long; hypanthium 3–7 mm. long, inner ring of hairs about one-third way from base; calyx lobes 0.4–1 cm. long, usually distinct and reflexed but occasionally partly or entirely united in anthesis, the tips often slightly free in bud; petals crimson to purple, sometimes with darker spot in center or at apex, cuneate to obovate, 0.5–2 cm. long, 0.5–1.5 cm. wide, not clawed, apex rounded, somewhat erose; filaments quite flat, dilated at base, 1–6 mm. long, unequal, the short set not over half as long as long ones; anthers subequal, 2–4 mm. long, yellow; style extending to tips of short stamens, frequently equaling long ones; stigma lobes about 1 mm. long and as broad, yellow or more commonly purple; capsule 1–3 cm. long, 3–5 mm. thick, usually conspicuously enlarged at center, strongly 8-ribbed, sessile or very short-pedicellate, not beaked, terete when growing, evidently quad-

rilateral in much of the dried material, varying in pubescence from glabrous to densely white- or yellow-lanate; seeds about 1 mm. long, slightly thicker, cresting minute.

Key to varieties

Leaves 1–1.8 cm. wide; capsule glabrate to pubescent; leaves seemingly glaucous.....*2a. G. purpurea* var. *typica*
Leaves 0.3–1.2 cm. wide; capsule pubescent to lanate; leaves not glaucous.....*2b. G. purpurea* var. *parviflora*

2a. GODETIA PURPUREA var. **typica** nom. nov.—*Oenothera purpurea* Curt. Bot. Mag. **10**:*t.* 352. 1796; T. and G. Fl. N. Amer. **1**:504. 1840, in part; S. Wats., Proc. Am. Acad. **8**:596. 1873, in part; *Godetia purpurea* G. Don *loc. cit.;* Jepson, Univ. Cal. Pub. Bot. **2**:344. 1907, in part; *Clarkia purpurea* Nels. and Macbr., BOT. GAZ. **65**:64. 1918, in part; *G. willdenowiana* Spach Hist. Veg. Phan. **4**:388. 1835; *G. lepida* var. *arnottii* Jepson Fl. W. Mid. Cal. 335. 1901; *G. arnottii* Jepson, Univ. Cal. Pub. Bot. **2**:346. 1907; *Clarkia arnottii* Nels. and Macbr., BOT. GAZ. **65**:64. 1918, in part; *Oe. prismatica* var. *dasycarpa* Leveille Monog. Onoth. 265. 1908, in small part.

Leaves broadly elliptic, 2–4 cm. long, 1–1.8 cm. wide, puberulent, yet appearing glaucous, the tips curved downward; capsule glabrate to pubescent.

Type locality, "Western Coast of North America."

Material examined, CALIFORNIA: Without locality, *Douglas* (G), *Brewer* 690 (C,G), 1842, *sub. nom. Oe. willdenowii*, authentic material *G. willdenowiana* (G); Solano Co., Elmira, *K. Brandegee* 121 (C,G,P,S), *K. Brandegee* 122 (C,G,P,S), *Baker* 2902 (G,P); Hartleys, *Baker* 2884 (C,G,P); Little Oak, *Jepson* in 1890, cited as typical material of *G. arnottii* (C); Marin Co., Tomales Point, *Newell* in 1905 (C); Sausalito, *Michener* and *Bioletti* 178 (G); Sacramento Co., Lincoln, *Hall* 10291 (C).

This variety is characterized by wide, seemingly glabrous leaves, which are curved downward at the tip, the capsule being glabrate to pubescent. *G. arnottii* of Jepson I place here; the two specimens he cites, from Little Oak, *Jepson*, and Elmira, *Baker*, resemble the illustration in the Botanical Magazine very closely. The type of *Oenothera arnottii* of TORREY and GRAY is entirely different and does not fit the description of JEPSON'S *Godetia arnottii*. I should judge from

the discussion of *Clarkia arnottii* by NELSON and MACBRIDE, *loc. cit.*, that they have JEPSON'S *G. arnottii* in mind, as they speak of the *Brandegee* collection's having both glabrous and puberulent capsules (collection from Elmira, Solano Co., Calif.). The two specimens they cite, however, do not belong there. The first, *Howell* 703, is *G. viminea* var. *typica*, and the other, *Sheldon* 10975, is *G. purpurea* var. *parviflora*.

2*b*. GODETIA PURPUREA var. **parviflora** (S. Wats.) comb. nov.—*Oenothera lepida* var. *parviflora* S. Wats., Proc. Am. Acad. **8**:597. 1873; *Oe. purpurea* T. and G. Fl. N. Amer. **1**:504. 1840, in part; S. Wats., *loc. cit.* 596, in part; *Godetia purpurea* Jepson, Univ. Cal. Pub. Bot. **2**:344. 1907, in part; *G. purpurea* var. *elmeri* Jepson, *loc. cit.* 345; *G. purpurea* var. *procera* Jepson, *loc. cit.* 346; *G. purpurea* var. *lacunora* Jepson, *loc. cit.*; *G. purpurea* var. *lucunarum* Jepson Man. Fl. Pl. Cal. 679. 1925; *Clarkia purpurea* Nels. and Macbr., BOT. GAZ. **65**:64. 1918, in part; *Oe. decumbens* Dougl., Curt. Bot. Mag. **56**:*t.* 2889. 1829; Bot. Reg. **15**:*t.* 1221. 1829; T. and G. Fl. N. Amer. **1**:504. 1840; *G. decumbens* Spach Hist. Veg. Phan. **4**:388. 1835; *Clarkia decumbens* Nels. and Macbr., *loc. cit.*; *Godetia lepida* Lindl., Bot. Reg. **22**:*t.* 1849. 1836; Jepson Fl. W. Mid. Cal. 335. 1901; *Oe. lepida* H. and A. Bot. Beech. Voy. 342. 1840; T. and G. *loc. cit.*; S. Wats., *loc. cit.* 597; *Oe. lepida* var. *arnottii* S. Wats., *loc. cit.*, in part; *G. albescens* Lindl., Bot. Reg. **27**: misc. 61. 1841; Jepson Fl. W. Mid. Cal. 334. 1901; *Oe. albescens* S. Wats., *loc. cit.*; *G. micropetala* Greene, Pittonia **1**:32. 1887; *G. goddardii* f. *capitata* Jepson, Univ. Cal. Pub. Bot. **2**:342. 1907; *G. goddardii* var. *capitata* Jepson Man. Fl. Pl. Cal. 678. 1925; *G. lanata* Elmer, BOT. GAZ. **41**: 317. 1906; *Oe. prismatica* var. *dasycarpa* Leveille Monog. Onoth. 265. 1908, in part; *Oe. pulcherrima* var. *brauntoni* Leveille *loc. cit.* 261, acc. to citation; *Clarkia arnottii* Nels. and Macbr., *loc. cit.*, in part, according to citation.

Leaves 0.3–1.2 cm. wide, lanceolate to spatulate, pubescent, never appearing glaucous, tips erect; capsule pubescent to densely lanate.

Type locality, Northern California.

Representative material, OREGON: Salem, *Nelson* 233 (S); Turner, *Nelson* 755 (S); CALIFORNIA: Humboldt Co., valley of Van Duzen R., *Tracy* 4244 (C); Butte Co., 8 mi. N. of Oroville, *Heller* 11384 (C,G,S); Clear Creek, *Brown*

212 (C,P,S); Berry Canyon, *Brown* and *Heller* 5472 (G,P,S); Sacramento Co., Sacramento, *Shockley* 404 (G); Sonoma Co., Santa Rosa, *Heller* 5646 (G); Marin Co., Tiburon, *Walker* 1736 (C); Sausalito Hills, *Sulliffe* in 1927 (P); San Francisco, near Twin Peaks, *K. Brandegee* in 1908 (P); San Mateo Co., *Dutton* in 1900 (S); Alameda Co., Oakland Hills, *Bolander* 410 (C,G); Berkeley, *Bioletti* in 1891, type of *G. purpurea* var. *procera* (C); Contra Costa Co., near Martinez, *Greene* in 1889, labeled *G. micropetala* (S); Mt. Diablo, *Greene* in 1886, probably type material of *G. micropetala* (C); San Joaquin Co., near Oakdale, *Jepson* in 1896, type material of *G. purpurea* var. *lacunora* (G,Jep); Mariposa Co., Lewis, *Congdon* in 1895 (G); Santa Clara Co., Los Gatos, *K. Brandegee* in 1905 (C); Santa Cruz Co., Santa Cruz, *Jones* in 1881 (P); Monterey Co., Lucia, *K. Brandegee* in 1909 (C); Tassajara Road, *Abrams* 5632 (P,S); San Luis Obispo Co., Santa Margarita Valley, *Mrs. Summers* in 1882 (C); Santa Barbara Co., Santa Barbara, *Elmer* 3791 (C,G,S), *Elmer* 3792, probably type material of *G. purpurea* var. *elmeri*, cited by Jepson as *Elmer* 3972 from Santa Barbara (C,G,S); Buellton, *Munz* 10299 (P); Ventura Co., Sulphur Mt., *Abrams* 4 (G, S); Los Angeles Co., hills N. of Los Angeles, *Lyon* 73 (G); Soldier's Home, Sawtelle, *Hasse* in 1890 (S); Elysian Park, *Braunton* in 1902 (S); San Diego Co., Cuyamaca Lake, *K. Brandegee* in 1906 (C), *Abrams* 3691 (G, S). The following collections deserve special mention because of the unusually lanate capsules: San Luis Obispo Co., Paso Robles, *Cobb* 10 (C); Arroyo Grande, *Summers* in 1886 (C); Monterey Co., between Castroville and Monterey, *K. Brandegee* in 1908 (C); Gigling, *Elmer* 4376, type collection of *G. lanata* (C,P,S); Fresno Co., Centreville, *Jepson* 2745, type of *G. goddardii* var. *capitata* (Jep).

In my opinion these forms show too much variation to be given even varietal rank. The type collection of *G. lanata* has some plants with densely lanate capsules and others that are sparsely so. The plant from Centreville, Fresno Co. (*G. goddardii* var. *capitata*), is practically identical with the type of *G. lanata*. The capsules are lanate and 2–3 cm. long; the inflorescence is practically restricted to the ends of the branchlets, and the flowers are nearly hidden by the leaves. It certainly belongs to the *G. purpurea* group. In fact, with its strongly ribbed capsules, flowers in dense clusters, rather short petals, leafy stems, and hairy ovaries, it would run directly to *G. purpurea* in JEPSON'S own key.

As stated, this variety is a heterogeneous group, which has been split up into numerous species and varieties, but after careful study it is considered advisable to treat it as a unit, rather than several poorly defined varieties, which it would be impossible to distinguish.

Some of the forms, such as a series from Elizabeth Lake, Los Angeles Co., *Hoffmann* in 1927 (P,SB), show every gradation from plants which are very evidently *G. purpurea* to those which resemble *G. quadrivulnera* very closely. In fact, it is frequently very difficult to distinguish *G. purpurea* var. *parviflora* from depauperate specimens of *G. quadrivulnera*.

3. GODETIA AMOENA (Lehm.) G. Don *in* Sweet Hort. Brit. ed. III, 237. 1839.

Erect, simple to diffusely branching; stems 1.5–10 dm. tall; leaf blades narrowly to broadly lanceolate, 2–6 cm. long, 0.2–1 cm. wide, acute to blunt, tapering to a petiole 0.5–1.5 cm. long; buds erect, or sometimes drooping slightly, 1–4 cm. long; hypanthium 4–10 mm. long, proportionately shorter in small-flowered forms, green or yellow on outside, white to greenish pink on inside, inner ring of hairs one-third to one-half way from base; calyx lobes 0.8–2.5 cm. long, generally united in anthesis, less commonly reflexed in pairs, or even all distinct; petals pale pink to purple, often with darker purple spot in center, or with dark purple base, cuneate to obovate, 1.5–4 cm. long, 1–3 cm. wide, tapering uniformly to base, or occasionally abruptly narrowed, forming a claw as much as 1.5 mm. long, apex rounded, truncate, or retuse, usually somewhat erose; filaments flattened, 2–12 mm. long, short set from one-half as long to nearly as long as long ones; anthers subequal, 5–12 mm. long, yellow or more commonly purple with yellow tips, tips usually sterile, but whole anther often either fertile or sterile; style varying in length from less than that of short stamens to nearly equal to long ones; stigma lobes varying from 1.5 mm. long to the more common type 3–7 mm. long, about 0.5 mm. wide, yellow; capsules 1.5–5 cm. long, 1.5–4 mm. thick, linear, or enlarged somewhat at or above the center, beakless, or with beak as much as 1 cm. long, sessile or with pedicel as much as 3 cm. long, at first (i.e., when immature) deeply 4-sulcate and with rather inconspicuous nerve between the grooves, at maturity and in dried material becoming terete with the intersulcate nerves showing plainly; seeds 0.5 mm. long, 1.5 mm. thick, brown, cresting not prominent.

Key to varieties

A. Stigma lobes linear, 2–7 mm. long.

B. Capsule enlarged above center; petals usually with large purple spot in center. Sonoma County, California

3a. G. amoena var. *sonomensis*

B. Capsule not enlarged above center; petals with or without purple spot.

C. Capsule 1.5–2 mm. thick, 4–5 cm. long, nearly sessile; petals never with spot. Butte County, California

3b. G. amoena var. *albicaulis*

C. Capsule usually over 2 mm. thick, less than 4 cm. long, usually pedicelled; petals with or without blotch. From Santa Cruz, California, to British Columbia

3c. G. amoena var. *typica*

A. Stigma lobes ovoid, not over 2 mm. long.

B. Capsule blunt or short-beaked. Plants of Oregon and Washington . . . . . *3d. G. amoena* var. *gracilis*

B. Capsule conspicuously beaked. Plants of Central California

3e. G. amoena var. *concolor*

3a. GODETIA AMOENA var. **sonomensis** var. nov.—Capsule sessile, considerably enlarged a little above the middle, blunt; petals 1.5–4 cm. long, dark lavender, usually with carmine or purple spot in center; stigma lobes 3–7 mm. long, linear. (Capsulae supra medio dilatatae, obtusae, sessiles; petalis maculatis.)

Type, ½ mi. E. of Glen Ellen, Sonoma Co., California, June 7, 1928, *C. L. Hitchcock* 18 (Pomona College Herb. no. 153238).

Other material examined, CALIFORNIA: Sonoma Co., Burke's Sanitarium, *Heller* 5752 (G,S); Glen Ellen, *Michener* and *Bioletti* in 1893 (C,G,P), *Michener* and *Bioletti* 682 (C); 3 mi. S.E. of Glen Ellen, *C. L. Hitchcock* 19 (P); Santa Rosa, *Heller* 5682 (G,P,S); 5½ mi. S. of Santa Rosa, *C. L. Hitchcock* 21 (P); near Healdsburg, *King* in 1897 (C); between Cloverdale and Geyserville, *M. S. Baker* 670 (C).

This variety is very showy. The petals usually have a crimson spot in the center but this is not always so. Capsules are long and decidedly enlarged above the middle. It is restricted to Sonoma Co., California.

3b. GODETIA AMOENA var. ALBICAULIS Jepson, Univ. Cal. Pub. Bot. **2**:329. 1907.

Capsule sessile or nearly so, 4–5 cm. long, 1.5–2 mm. thick, linear, beak 5–10 mm. long; petals 2–4 cm. long, light lavender, without spot; stigma lobes 3–6 mm. long, linear.

Type locality, Rancho Chico, Butte Co., California.

Material examined, CALIFORNIA: Butte Co., *Mrs. Austin* 34 (C,P), *Fremont* 438 (G); Shasta Co., Pitt River, *Smith* 315 (G); Butte Co., Lemmon's Ranch, *Lemmon* 4546 (G); Chico, *Mrs. Bidwell* in 1879 (G); Little Chico, *Mrs. Bruce* 1954 (P,S); banks of Little Chico Creek, July, 1896, 848 (C); De Salba, *Edwards* in 1917 (P,S).

3c. GODETIA AMOENA var. **typica,** nom. nov.—*Oenothera amoena* Lehm., Ind. Sem. Hort. Hamb. 8. 1821; Pugill. Pl. **1**:811. 1828; T. and G. Fl. N. Am. **1**:503. 1840; S. Wats., Proc. Am. Acad. **8**:599. 1873; *Godetia amoena* G. Don *loc. cit.;* Lilja *in* Linnaea **15**:265. 1841; Jepson, Univ. Cal. Pub. Bot. **2**:325. 1907; *Clarkia amoena* Nels. and Macbr., BOT. GAZ. **65**:62. 1918; *G. amoena* f. *pygmaea* Jepson, *loc. cit.* 328; *G. amoena* var. *pygmaea* Jepson Man. Fl. Pl. Cal. 677. 1925; *G. amoena* f. *huntiana* Jepson, Univ. Cal. Pub. Bot. **2**:329. 1907; *G. amoena* var. *huntiana* Jepson Man. Fl. Pl. Cal. 677. 1925; *G. amoena* var. *lindleyi* Jepson, Univ. Cal. Pub. Bot. **2**:329. 1907; *Clarkia amoena* f. *lindleyi* Nels. and Macbr., *loc. cit.; Oenothera prismatica* var. *amoena* Lev. Monog. Onoth. 266. 1908, in part; *Oe. roseoalba* Bernh., Ind. Sem. Hort. Erford (1824), *ex Reichb.* Ic. Bot. Exot. **1**:34, pl. 47. 1827; Sweet Brit. Fl. Gard. *t.* 268. 1828; *Oe. lindleyi* Dougl., Bot. Mag. **55**:*t.* 2832. 1828; T. and G. *loc. cit.*, 503; *Godetia lehmanniana* Spach Hist. Veg. Phan. **4**:391. 1835, Nouv. Ann. Mus. Par. III, **4**:392. 1835; *G. lindleyana* Spach Hist. Veg. Phan. **4**:392. 1835, Nouv. Ann. Mus. Par. III, **4**:392. 1835; *Oe. lindleyana* Steud. Nom. ed. II, **2**:207. 1841; *G. rubicunda* Lindl., Bot. Reg. **11**:*t.* 1856. 1836; *Oe. rubicunda* H. and A. Bot. Beech. Voy. 342. 1840; T. and G. *loc. cit.* 502; *G. vinosa* Lindl., Bot. Reg. **22**:*t.* 1880. 1836; *Oe. vinosa* T. and G. *loc. cit.* 503; *Oe. macrantha* Nutt. *in* H. and A. Bot. Beech. Voy. 342. 1840; *G. macrantha* Lilja, Tidnung (1840), *ex cod. in* Linnaea **15**:265. 1841; *G. grandiflora* Lindl., Bot. Reg. **27**: misc. p. 61. 1841; Jepson, Univ. Cal. Pub. Bot. **2**:347. 1907, in part; *Oe. grandiflora* Wats., Proc. Am. Acad. **8**:596. 1873, in part; *G. cau-*

rina Abrams *ex* Piper, Contr. U. S. Nat. Herb. **11**:410. 1906; *Clarkia caurina* Nels. and Macbr., Bot. Gaz. **65**:62. 1918; *G. blasdalei* Jepson, *loc. cit.* 330; *Clarkia superba* Nels. and Macbr., *loc. cit.* 60.

Capsule usually pedicelled, not noticeably enlarged above center, blunt or short beaked; petals 1–4 cm. long, light pink to purple, with or without central blotch or base of purple; stigma lobes 2–7 mm. long, linear.

Type locality, "America septentrionalis."

Representative material, without locality: "*e Lehmann ipse*," authentic material of *O. amoena* (G); "*Godetia vinosa* Lindl. Spach M. Par.," authentic material of *G. vinosa* (G); "*Spach*, M. Paris 1838," authentic material of *G. rubicunda* (G); "*Oe. lindleyi, cult., Sartwell e. Sem. Hort. Soc. Lond.* 1833" (G); BRITISH COLUMBIA: Victoria, *Macoun* 283 (G); WASHINGTON: between Olympia and Gate City, *A. A.* and *E. G. Heller* 4051 (C,G,P,S); Olympic Mts., *Elmer* 2565, type collection of *G. caurina* (S); Chenowith, *Suksdorf* 2129 (C,G); OREGON: without locality, *Nuttall* 1866, type of *Oe. macrantha* (G); Willamette R., below Portland, *Sheldon* 10864 (G,P,S); Eugene, *Nelson* 330 (S); CALIFORNIA: Siskiyou Co., Klamath R., *Butler* 747 (S); Del Norte Co., Crescent City, *Kildale* 1035 (S); Humboldt Co., Shelter Cove, *Tracy* 4998 (C); Garberville, *Abrams* 8229 (P,S); Trinity Co., Duzen R., *Abrams* 6020 (S); Shasta Co., Mt. Shasta, *Hall* and *Babcock* 4088, small-flowered form (C); Plumas Co., *Mrs. Ames* 1875 (G); Mendocino Co., Comptche, *Walker* 385 (C); Lake Co., Blue Lakes, July 16, 1897, *Jepson* 13336, type *G. amoena* f. *huntiana* (Jep); Saratoga Springs, *Jepson* 13338 (Jep); Colusa Co., 3 mi. W. of Leesville, *Heller* 12354 (G,S); Napa Co., Calistoga, *K. Brandegee* 120 (C,G,P,S); Conn Valley, May 1, 1894, *Jepson* 13339, type of *G. amoena* f. *pygmaea* (Jep); Sonoma Co., Glen Ellen, *K. Brandegee* in 1908 (C,P); Marin Co., Olema, *Elmer* 4436 (C,P,S); Tiburon Peninsula, *Heller* 5726 (G,P,S); Alameda Co., Oakland Hills, *Bolander* in 1865 (C,G); Cedar Mt., *Elmer* 4436 (C,P,S); Contra Costa Co., 2 mi. S. of Dublin, *C. L. Hitchcock* 16 (P); San Francisco, between Baker's Beach and Land's End, *K. Brandegee* in 1906 and 1907 (C); San Mateo Co., near Crystal Springs Lake, *Elmer* 4310 (C,P,S); Milbrae, *Eastwood* 331 (G); Santa Cruz Co., Watsonville, *Elmer* 5053 (C,P,S); grade above Santa Cruz, *C. L. Hitchcock* 12 (P); Santa Clara Co., Mission Peak, San Jose, *Brewer* in 1864 (G); Saratoga, *Pendleton* 395 (C); foothills W. of Los Gatos, *Heller* 7479 (C,G,S); NEVADA: Ormsby Co., Ash Canyon, *Baker* 980, small-flowered (P); Carson City, *Jones* in 1897, small-flowered (P).

Excepting *G. quadrivulnera*, *G. amoena* has the greatest distributional range of any species of *Godetia*, and is one of the most variable. Several species have been described from color variants, among them *G. vinosa*, *G. rubicunda*, *G. roseo-alba*, and *G. lindleyi*. Coloration is so

variable here that I am unable to recognize these even as varieties, although there does seem to be some tendency for the northern forms to have spotted petals, but much of the material from the San Francisco Bay region also shows this coloration. The length of capsule, length of pedicel, size and coloration of petals, beaking of capsule, and even the length of stigma lobes all vary greatly.

G. caurina was described from a plant with glabrous anthers, but is identical with *G. amoena* in every other respect. Due to the fact that the pubescence of the anthers is so scattered that it is difficult to distinguish, and because other plants examined from the same locality do have a few scattered hairs on the anthers, their mere presence or absence does not seem to merit nomenclatural recognition.

G. amoena var. *pygmaea* was described from a depauperate specimen. In its subsessile capsule, which is slightly thickened upward, it suggests the var. *sonomensis* and is intermediate between that variety and var. *typica*. *Huntiana* is also considered unworthy of recognition. The type from Blue Lakes is not an unusual form. The "3-forked blotch" is not uncommon; for example, a specimen from 20 mi. N. of Laytonville, Mendocino Co., *Munz* 9884 (P), has petals with a three-forked blotch in the center but is typical material in every respect. The petals of *Jepson's* plant are 1.8 cm. long, which is near the average. The other specimen cited by JEPSON in his original description, from Saratoga Springs, appears to have had the top eaten off, so that it is not strange if the resulting growth was somewhat unusual.

There are several local variants worthy of mention. *K. Brandegee* made several collections from McDowell Avenue, San Francisco, that have truncate petals, the base red, central portion yellow and apex lavender. Several collections from the north side of San Francisco Bay, among them: Pt. Isabel, *Blasdale* in 1893, type of *G. blasdalei* (C), *K. Brandegee* in 1908 (C,P); ½ mi. N. of Tiburon, *C. L. Hitchcock* 25 (P), have rather thick capsules, and petals that are often retuse, although all the flowers on one plant are not alike in this respect. Plants of high altitudes usually have small flowers with all the parts reduced.

Godetia amoena can usually be distinguished from *G. bottae* by the longer hypanthium and stigma lobes, but occasionally individuals

are found that have as short hypanthia as the latter species. In the field they can readily be told by the difference in the immature capsule, that in *G. amoena* being 4-sulcate and that in *G. bottae* being terete and faintly nerved. With dried material, the only way to distinguish between the two species is by the position of the inner ring of hairs on the hypanthium. In *G. amoena* this ring is found at a point below the middle, in *G. bottae* it is above the middle.

3d. GODETIA AMOENA var. **gracilis** (Piper) comb. nov.—*Godetia gracilis* Piper *in* Piper and Beattie Fl. N. W. Coast 251. 1915; *Clarkia gracilis* Nels. and Macbr., BOT. GAZ. **65**:63. 1918.

Capsule nearly sessile, blunt or short beaked; petals 1–2 cm. long, stigma lobes oval, about 1 mm. long.

Type locality, Silvertown, Oregon.

Representative material, BRITISH COLUMBIA: near Victoria, *Fletcher* 811*a* (G); WASHINGTON: Klickitat Co., *Suksdorf* 23 (G); Bingen, *Suksdorf* 5606 (G); Walla Walla region, *Tweedy* in 1883 (S); Vancouver Island, *Macoun* 42 (G), *Rosendahl* 1849 (G); OREGON: Josephine Co., Takilma, *Peck* 7928 (G); Waldo, *Abrams* and *Benson* 10366 (S); Clakamas Co., Willamette Falls, *Sheldon* 12216 (S); Crook Co., Grizzly Butte, *Leiberg* (G,P,S); Hood River, *Henderson* in 1882 (S); summit of Parrott Mt., *Nelson* 2719 (G); Oregon, *Elihu Hall* 192, type collection of *G. gracilis* (G). The following are intermediate between var. *gracilis* and var. *typica:* Friday Harbor, San Juan Islands, Washington, *Dr.* and *Mrs. Zeller* 897 (G); Hood River Co., *Henderson* 834 (G).

This variety is characterized by the rather small flowers, very short beaked capsule and short stigma lobes. Since it has the characteristic terete, nerved capsule of *G. amoena* when dried, it is not deemed deserving of specific rank.

3e. GODETIA AMOENA var. CONCOLOR Jepson Fl. W. Mid. Cal. 334. 1901.—*Clarkia amoena* f. *concolor* Nels. and Macbr., BOT. GAZ. **65**:62. 1918.

Capsule pedicelled, beak 3–7 mm. long; petals 1–1.5 cm. long; stigma lobes oval, about 1 mm. long.

Type locality, Pope Valley Grade, Napa Co., California.

Material seen, Pope Valley Grade, *Jepson* 13337, type (Jep); *K. Brandegee* in 1909 (C,P,S); El Dorado Co., New York Ravine, *K. Brandegee* in 1907 (C,P); Butte Co., *Mrs. Bruce* 2419 (P); Kelsey, *Jones* in 1883 (P). The following collection approaches this variety: Yolo Co., Cache Creek Canyon, *Baker* 2891 in part (G,P).

This variety is easily confused with small-flowered forms of *G. amoena* var. *typica*. The stigma lobes, as in var. *gracilis*, are much shorter than in the typical form. It resembles var. *gracilis* very closely but has a well beaked capsule, while the capsule in the latter variety is not beaked.

4. GODETIA WHITNEYI (Gray) T. Moore Flor. and Pomol. 101. 1871.—*Oenothera whitneyi* Gray, Proc. Am. Acad. **7**:340. 1865; *Clarkia whitneyi* Nels. and Macbr., BOT. GAZ. **65**:61. 1918; *Oe. auricula* var. *whitneyi* Leveille Monog. Onoth. 270. 1908; *Oe. grandiflora* Wats., Proc. Am. Acad. **8**:596. 1873, in part; *Godetia grandiflora* Jepson, Univ. Cal. Pub. Bot. **2**:347. 1907, in part.

Erect, stout, simple or with closely crowded branches above; stems 2–4.5 dm. tall, finely pubescent; leaf blades lance-ovate to ovate, 3.5–6 cm. long, 0.8–1.5 cm. wide, acute to acuminate, petiole 2–10 mm. long; inflorescence finely pubescent; buds erect, 3–4 cm. long, acuminate; hypanthium broad at top, 6–9 mm. broad in pressed specimens, 8–11 mm. long, ring of hairs within about one-third way from base; calyx lobes 1.5–3 cm. long, united in anthesis, tips not free in bud; petals lavender with a splotch of deep red or purple toward base, cuneate to obovate, 4–6 cm. long, 2.5–4 cm. wide, rounded to retuse at apex, rather abruptly narrowed at base to form a 1.5–2 mm. claw; filaments unequal, 3–9 mm. long, strap-shaped, dilated at base; anthers subequal, 9–15 mm. long, purple, tinged with yellow above, fertile to tip; style 2.5–3 cm. long, exceeding stamens, extending half the length of petals; stigma lobes linear, yellow, 6–7 mm. long; ovary densely canescent; capsule broadly fusiform, 1.5–2.5 cm. long, 0.5–0.7 cm. thick, round in cross-section, with 8 prominent ribs, sessile or with pedicel as much as 3 mm. long; seeds 1.5 mm. long and half as thick, brown, covered with minute cellular pubescence, cresting fairly pronounced.

Type locality, Shelter Cove, Humboldt Co., California.

Material seen, Shelter Cove, *Bolander* 6534, type collection of *Oe. whitneyi* (C,G); *Peirson* in 1927 (P); California, *Vasey* in 1876 (G); from *Thomson's* seeds in 1871 (G). There are also several sheets from *Burbank's* garden (C), which are evidently of this species.

WATSON combines this species with *Oe. grandiflora*, and so does JEPSON. But as NELSON and MACBRIDE, BOT. GAZ. **65**:60. 1918,

point out, the description of *Oe. grandiflora* says "fructu lineari 4-sulcato tereti pubescente," a character which proves the relationship of that species to *G. amoena*, the only species of *Godetia* with a 4-sulcate capsule. *G. whitneyi* certainly does not have either a 4-sulcate or a linear capsule, and, as GRAY pointed out in describing it, it is related to *G. purpurea* in habit and capsule character; on the other hand, it is similar to *G. amoena* in hypanthium, stigma lobes, and filaments.

5. GODETIA VIMINEA (Dougl.) Spach Hist. Veg. Phan. 4:388. 1835.

Erect, branching from middle, more rarely from base, frequently simple; stems 1.5–10 dm. tall, finely white-pubescent; flowering branches short or as much as 40 cm. long; leaf blades lance-oblong to spatulate, 2–5 cm. long, 0.2–0.6 cm. wide, acute to rounded at apex, short petioled; buds erect, 1.5–2.5 cm. long and one-third as thick, tapering very abruptly at apex to a point 0.5 mm. long; hypanthium 0.6–1.2 cm. long, slender, green or yellow, tinged with lavender, inner ring of hairs about one-third way from base; calyx lobes 0.7–1.4 cm. long, greenish-yellow, reflexed in pairs, or more commonly all distinct in anthesis, the tips usually slightly free in bud, very finely pubescent to rather densely pilose; petals cream-yellow at base, with large central purple spot, crimson with purple spots, or plain lavender or purple 1.3–2.5 cm. long, 1–2.2 cm. wide, cuneate, without claw, the apex rounded and usually somewhat erose; filaments strap-shaped, dilated at base, 2–6 mm. long, unequal, the long set about three times as long as others; anthers subequal, 5–7 mm. long, white or yellow or more rarely lavender; style equaling or slightly exceeding longer stamens; stigma lobes elliptic, about 1.5 mm. long and one-third as broad, yellow to deep purple; young ovaries very short, approximately one-third length of bud, pubescent to pilose; capsule 1–3 cm. long, 2–4 mm. thick, plainly 8-ribbed, in pressed specimens often appearing quadrilateral, sessile or with pedicel 2 mm. long, with beak about 1 mm. long; seeds 0.75 mm. long, slightly broader, smooth, cresting inconspicuous.

Key to varieties

A. Capsules usually somewhat enlarged at center; petals not spotted
5*a*. *G. viminea* var. *typica*

A. Capsules linear, or at least not enlarged at center; petals usually spotted.

B. Petals yellow toward base.....5*b*. *G. viminea* var. *williamsonii*

B. Petals crimson.....5*c*. *G. viminea* var. *incerta*

5*a*. GODETIA VIMINEA var. **typica,** nom. nov.—*Oenothera viminea* Dougl. *ex* Hook., Bot. Mag. **55**:*t.* 2873. 1828; T. and G. Fl. N. Am. **1**:503. 1840, in part; S. Wats., Proc. Am. Acad. **8**:598. 1873; *Godetia viminea* Spach, *loc. cit.;* Jepson, Univ. Cal. Pub. Bot. **2**:336. 1907, in part; *Clarkia viminea* Nels. and Macbr., BOT. GAZ. **65**:64. 1918, in part; *Oe. arnottii* T. and G. *loc. cit.; G. arnottii* Walp. Rep. **2**:88. 1843; *C. arnottii* Nels. and Macbr., *loc. cit.*, in part, from citation; *Oe. lepida* var. *arnottii* S. Wats., *loc. cit.*, 597, in part; *Oe. auricula* var. *tenella* subvar. *williamsonii* f. *vimineiformis* Leveille Monog. Onoth. 272. 1908.

Petals lavender; anthers yellow; capsule enlarged at center, 3–4 mm. thick; flowers borne in compact spikes; hypanthium 6–9 mm. long.

Type locality, interior of northern California.

Representative material, OREGON: Coast ranges, *Howell* and *Henderson* in 1882 (G); Multnomah Co., *Howell* 138 (G); Eugene, *Bradshaw* 1749 (S); Monroe, *Munz* 9900 (P,S); Grant's Pass, *Henderson* 356 (C,S); the Dalles, *C. Davidson* (P); CALIFORNIA: El Dorado Co., Blue Ravine, *K. Brandegee* in 1907 (C); Sweetwater Creek, *K. Brandegee* in 1908 (C); Mendocino Co., Leggett Valley, *Munz* 9883 (P,S); Humboldt Co., near Garberville, *Munz* 9887 (P); Humboldt Co., Dinsmore's Ranch, *Tracy* 3957 (G); Marin Co., Olema, *K. Brandegee* in 1908 (P), *Walker* 1199 (C); Oakland Hills, *Bolander* 282 (G); Stanislaus Co., Knight's Ferry, *Dr. Bigelow* (G); Ventura Co., Sulfur Mts., *Abrams* and *MacGregor* in 1908, capsules unusually pilose (G,P,S); California, *Douglas*, type of *Oe. arnottii* (G); foothills W. of Los Gatos, *Heller* 7446 (G,S).

JEPSON, Univ. Cal. Pub. Bot. **2**:336. 1907, calls attention to the fact that *G. viminea* and *G. williamsonii* are very closely related and he treats the latter as a synonym of the former. I find, however, that the material from Oregon and from central coastal and northern California has a larger, thicker capsule than the material from the Sierra Nevadas, and the flowers in the material from the former localities are less inclined to be spotted. The plate in the Botanical Magazine shows an unspotted flower, and a later plate of *Oe. viminea*, Bot. Reg. **15**:1220. 1829, represents a plant with large,

thick capsules and faintly spotted petals. Because of the fact that there seems to be this difference between the Sierra Nevadan plants and the others, the groups are kept as varieties. The type of *Oe. arnottii* resembles *G. viminea* var. *typica* in size and coloration of petals, and in type of inflorescence. It certainly is not in any way like *G. arnottii* Jepson, which is "wholly glabrous; calyx tube 3 mm. long; petals 1.3 cm. long," as the *Douglas* specimen is sparingly pubescent, and has a 6 mm. calyx tube, and petals 1.6 cm. long.

5*b*. GODETIA VIMINEA var. **congdonii** Jepson Univ. Cal. Pub. Bot. **2**:338. 1907. *Godetia williamsonii* Dur. and Hilg., Pac. R. R. Rep. 5^3:7. 1855; *Oenothera williamsonii* S. Wats., Proc. Am. Acad. **8**:597. 1873; *Oe. auricula* var. *tenella* subvar. *williamsonii* Leveille Monog. Onoth. 271. 1908; *Oe. viminea* T. and G. Fl. N. Am. **1**:503. 1840, in part; *G. viminea* Jepson, Univ. Cal. Pub. Bot. **2**:336. 1907, in large part; *Clarkia viminea* Nels. and Macbr., BOT. GAZ. **65**:64. 1918, in part; *Oe. prismatica* var. *viminea* Leveille *loc. cit.* 265.

Petals yellow to lavender with purple spot in center; anthers yellow; capsule not enlarged at center, usually not over 2 mm. thick; flowers scattered on long flowering branches; hypanthium 0.8–1.2 cm. long.

Type locality, Hetch-Hetchy Valley, Tuolumne Co., California.

Representative material, CALIFORNIA: without locality, *Bridges* 107 (G); *Hartweg* 1727 (G); *Bolander* 6367 (C,G); Shasta Co., Pitt to Baird, *Eastwood* 1405 (G); Sierra Co., Sierra Valley, *Lemmon* in 1873 (G); El Dorado Co., near Fyffe, *K. Brandegee* in 1908 (G,P); Nevada Co., near Wolf Creek, *Eastwood* 3442 (G); Amador Co., 5 mi. N.E. of Jackson, *C. L. Hitchcock* 31 (P); New York Falls, *Hansen* 36 (C,P,S); Tuolumne Co., Hetch-Hetchy Valley, *Congdon* in 1896, type of *G. viminea* var. *congdonii* (C,G); Hog Ranch, *Congdon* in 1896 (G); Mariposa Co., Westfall Road, *Congdon* in 1895 (G,S); above Yosemite, *Lemmon* 246 (G); Yosemite, *Spencer* in 1917 (G); Wawona, *Abrams* 5402 (S); Madera Co., Raymond, *Mrs. Tompkins* in 1894 (S); Tulare Co., Middle Tulare R., *Purpus* 5574 (G); Fresno Co., Big Sandy Creek, *MacDonald* in 1915 (G); near Toll House, *Hall* and *Chandler* 15 (C); Pine Ridge, *Hall* and *Chandler* 203 (S); Kern Co., vicinity of Poso Creek Valley, *Dudley* 563 and 550 (S); Tejon Canyon, *Coville* and *Funston* 1217 (C). Several collections from Live Oaks, Mokelumne R., *Rattan* in 1885 and in 1886 (G,S), are peculiar in that the flowering spike is greatly shortened.

Variety *congdonii* shows considerable variation in the pubescence of calyx lobes and young capsules. For example, in a collection from

Hetch-Hetchy Valley, *Bioletti* in 1900 (C), the lobes are pilose; in that of *Chestnut* and *Drew* in 1889, from same locality (C), the capsule is pilose but the calyx lobes are not, and in the following collections individual plants can be found which have some flowers with pilose lobes, while others have merely pubescent ones: Tuolumne Co., Hog Ranch, *Hall* and *Babcock* 3313 (C, P); El Dorado Co., 12 mi. E. of Placerville, *K. Brandegee* in 1908 (C); Amador Co., near Jackson, *Mullikin* 115 (C,S).

5*c*. GODETIA VIMINEA var. INCERTA Jepson, Univ. Cal. Pub. Bot. 2:339. 1907.

Petals crimson with deeper-colored spot in center; anthers yellow or lavender; capsule not enlarged at center, about 2 mm. thick; flowers borne in long, loose spikes; hypanthium 0.8–1.2 cm. long.

Type locality, Yosemite Valley, California.

Representative material, CALIFORNIA: Yosemite Valley, *Parish* 4219 (S), *Cook* and *Reynolds* (P), *Mrs. Bacon* in 1902 (S), *Kennedy* 3022 (C), *Redfield* 116 (C), *Hall* in 1900 (C), *Hall* 9109 (C), *Mrs. Tompkins* in 1894 (S), *S. H. B.* in 1894 (S), *Parry* (S), *M. S. Baker* 43c–25 (S); Tulare Co., Eshome Valley, *Mrs. Clemens* in 1910 (P).

6. GODETIA PARVIFLORA (H. and A.) Jepson, Univ. Cal. Pub. Bot. 2:339. 1907.

Erect and simple, or more commonly branching from base and ascending; stems 1–4 dm. tall, branches filiform and wiry; leaf blades linear-lanceolate to oblanceolate, 1–4 cm. long, 1.5–5 mm. broad, acuminate to rounded, short petioled; buds erect, 1.5–2.5 cm. long, acuminate; hypanthium slender to broad at summit, 0.5–1.5 cm. long, usually having a swelling at top of ovary, ring of hairs within one-fifth to one-third way from base; calyx lobes 0.5–1.5 cm. long, green to rose, united in anthesis, reflexed in pairs, or all distinct, the tips sometimes free in bud; petals varying in color from cream with crimson spot in center to cream or yellow at base and crimson above, with or without spots, or light crimson with deeper-colored spot, or petals solid crimson, triangular to obovate, 1–2.5 cm. long, 0.7–2.5 cm. wide, apex truncate to rounded, without claw; filaments unequal to subequal, 1–6 mm. long, broadly strap-shaped, dilated slightly at base; anthers subequal, 3–7 mm. long, yellow to lavender; style equaling longest anthers or nearly equaling petals; stigma lobes

oval or linear, 1.5–3 mm. long and one-third as broad, lavender to purple; capsule 1–2.5 cm. long, 0.1–0.2 cm. wide, 8-ribbed, in fresh specimens terete but in dried specimens apparently quadrilateral, pubescent, usually conspicuously curved, sessile or with pedicel as much as 2 mm. long, not beaked or with very short beak; seeds nearly equilateral, 1 mm. long, dark brown, cresting minute.

Key to varieties

A. Filaments subequal; style usually exceeding longer stamens; petals solid crimson, with or without purple spot toward base ..... *6a. G. parviflora* var. *typica*

A. Filaments unequal; style usually about equaling longer stamens; petals not solid crimson.

B. Anthers lavender; stigma lobes lavender; petals cream with purple spot ..... *6b. G. parviflora* var. *luteola*

B. Anthers yellow; stigma lobes purple; petals red with yellow base ..... *6c. G. parviflora* var. *margaritae*

6a. GODETIA PARVIFLORA var. **typica,** nom. nov.—*Godetia parviflora* Jepson, Univ. Cal. Pub. Bot. **2**:339. 1907, in part; *Oenothera viminea* var. *parviflora* H. and A. Bot. Beech. Voy. 342. 1840; *Oe. tenella* Wats., Proc. Am. Acad. **8**:598. 1873, in part; *G. quadrivulnera* var. *tenella* Jepson Fl. W. Mid. Cal. 334. 1901, in part.

Filaments subequal, 1–4 mm. long; anthers usually lavender; hypanthium 0.7–1.5 (usually about 1) cm. long; style exceeding longer stamens, nearly equaling petals; stigma lobes purple; petals cuneate, 1–2 cm. long, 0.8–2 cm. wide, tapering very uniformly to base; apex rounded, truncate or even retuse, crimson with central spot of purple or solid crimson; capsules 1–1.5 cm. long.

Type locality, Monterey, California.

Representative material, CALIFORNIA: San Luis Obispo Co., Cholami, *Lemmon* 4567 and 4587 (G); Paso Robles, *Cobb* 3 and 15 (C); Santa Margarita, *K. Brandegee* in 1911 (C); 3½ mi. E. of Templeton, *Wiggins* 2070 (S); 3 mi. S. of Atascadero, *C. L. Hitchcock* 8 (P); La Panza, *Mrs. Summers* in 1888, branches stouter than usual (C); Monterey Co., Jolon Valley, *Hall* 9974 (C); Jolon, *K. Brandegee* 77 and 123 (C,G,P,S); Santa Lucia Mts., *K. Brandegee* in 1909 (C); between Jolon and San Antonio Mission, *Abrams* 6487 (P,S); San Antonio Creek, above Mission, *Dudley* in 1895 (S); Salinas Valley, *Brewer* 519 (C,G); "California," *Douglas*, type material (G); Ventura Co. (?-probably wrong locality), *Sweet* in 1917 (S).

It is doubtful whether *G. parviflora* should be considered a distinct species, or a variety under *G. viminea*. The rather striking coloration, the filiform basal branching and the strongly curved capsule, however, seem to separate it clearly. If one recognizes *G. parviflora* as specific, var. *margaritae* and var. *luteola* must be considered as related forms, since they also have basal branching and curved capsules. This would mean two rather closely related species, with *G. parviflora* confined to the coast from San Luis Obispo to Santa Cruz, and *G. viminea* and varieties confined largely to the interior.

The description of *Oenothera tenella* Cavanilles, Icon. **4**:66, *t.* 396. 1797, does not fit the species, and the plate shows a plant with very strongly angled capsules. The plate in the Botanical Magazine, **50**:*t.* 2424. 1823, does not resemble *G. parviflora;* the coloration is different, the long hypanthium is not in evidence, and the capsules are not curved. The material from South America, labeled *G. tenella*, resembles *G. quadrivulnera* more than it does *G. parviflora*, but is not identical with either. Due to this uncertainty I consider it wise to reject the name for North American plants until the species from the Southern Hemisphere can be more thoroughly studied.

6*b*. GODETIA PARVIFLORA **luteola** var. nov.—Filaments unequal, 1–3 mm. long, long ones about twice the length of others; anthers yellow; hypanthium usually about 1 cm. long; style equaling longer stamens; stigmas lavender; petals cuneate-obovate, 1–2 cm. long, 0.8–1.5 cm. wide, apex rounded, cream with large central crimson spot; capsules 1–1.5 cm. long. (Antherae luteolae; stigmatibus ostrinibus; petalis ochroleucis cum magna sanguinea macula.)

Type, top of grade on road between Atascadero and Morro Beach, San Luis Obispo Co., California, June 17, 1928, *C. L. Hitchcock* 40 (Pomona College Herb. no. 153223).

Other material: McGinnis, 25 mi. N.E. of San Luis Obispo, *Palmer* 143 (C,G); Atascadero to Atascadero Beach, *Abrams* 7653 (S).

This peculiar form was first noticed in the Gray Herbarium material. As an opportunity came to collect in the San Luis Obispo region in the summer of 1928, I searched for these plants and found them growing in abundance in this spot (type locality).

6*c*. GODETIA PARVIFLORA var. **margaritae** (Jepson) comb. nov.—*Godetia viminea* var. *margaritae* Jepson, Univ. Cal. Pub. Bot. **2**:339. 1907.

Filaments unequal, 2–6 mm. long, the longer ones two to three times as long as the others; anthers lavender; hypanthium 0.3–1.2 (usually about 0.6) mm. long; style equaling longer stamens; stigma lobes purple; petals cuneate-obovate, apex rounded, 1.2–2.5 cm. long, 1–2.5 cm. wide, base yellow, upper part wine-colored, red or dark lavender, occasionally with light red spot in center; capsules 1–2.5 cm. long.

Type locality, Santa Margarita Valley, San Luis Obispo Co., California.

Material examined, CALIFORNIA: San Luis Obispo Co., road from Arroyo Grande to Huasna, *Eastwood* 14990 (P); highway between Pismo and Arroyo Grande, *C. L. Hitchcock* 42 (P); sandhills near Pismo Beach, *Abrams* 6519 and 6520 (S); Price Canyon, *K. Brandegee* 126 (C,G,P,S), *C. L. Hitchcock* 4 and 36 (P); near San Luis Obispo, *Lemmon* 4615 (G); Santa Margarita Valley, *Mrs. Summers* in 1882, in part (C), *Mrs. Summers* 323, type of *G. viminea* var. *margaritae* (C).

Although the type of *G. viminea* var. *margaritae* is very badly faded, I believe it is identical with the material from Pismo Beach and vicinity; the large flowers, with red and yellow petals, are very conspicuous. As previously stated (*cf.* discussion under *G. parviflora* var. *typica*), this variety shows much closer affinity to *G. parviflora* than to *G. viminea*, where it was placed by JEPSON, and for this reason I am transferring it to the former species.

7. GODETIA HISPIDULA S. Wats., Bot. Calif. **1**:231. 1876.—*Oenothera hispidula* Wats., Proc. Am. Acad. **8**:599. 1873; *G. arcuata* Jepson, Univ. Cal. Pub. Bot. **2**:335. 1907; *G. hansenii* Jepson, *loc. cit.* 336; *Oe. pulcherrima* Leveille Monog. Onoth. 261. 1908, in part, according to citations; *Clarkia arcuata* Nels. and Macbr., BOT. GAZ. **65**:62. 1918.

Erect, simple or branching from base; stems 1–6.5 dm. tall; leaf blades linear to spatulate, 1–5 cm. long, 0.1–0.4 cm. wide, acuminate to rounded at apex, short petioled, inflorescence usually glandular-pubescent; buds nodding, 1–2.5 cm. long, acute; hypanthium slender, 4–9 mm. long, with or without a slight swelling at top of ovary, green without, usually purple within, inner ring of hairs about one-

third way from base; calyx lobes green to rose, 0.5–1.5 cm. long, united in anthesis, the tips not free in bud; petals lavender to lilac, rather broadly cuneate, 1–2.8 cm. long, 0.8–2.6 cm. wide, rounded to retuse at apex, not clawed; filaments slightly flattened, 2–8 mm. long, unequal, long ones twice the length of short ones, anthers subequal, 2–7 mm. long, yellow to violet, fertile to tip; style 1.6–3 cm. long, extending to about half way between tips of long stamens and apex of petals; stigma lobes linear, 2–3 mm. long, white or yellow; capsule 1–3 cm. long, rounded at base and borne on pedicel 2–7 mm. long, tapering to slender beak 3–6 mm. long, 8-ribbed, in dried specimens appearing quadrilateral with a small nerve showing in each intercostal space, more or less pubescent with tiny pin-head glands; seeds dark brown, 1–5 mm. long, cellular-pubescent, cresting one-fourth as long as seed proper.

Type locality, not given.

Material examined, CALIFORNIA: Butte Co., Chico, *Mrs. Bidwell* in 1885 (G); Rancho Chico, *Mrs. Bidwell* in 1878 (G); El Dorado Co., near Placerville, *K. Brandegee* in 1907 (C); Sportsman's Hall, 12 mi. above Placerville, *K. Brandegee* in 1907 (C); Sweetwater Creek, *K. Brandegee* in 1908 (C); between Coal and Auburn, *K. Brandegee* in 1908 (C); Amador Co., Armstrong's Station, *Hansen* 1090, type collection *G. hansenii* (C,G); near Wylie's Station, *K. Brandegee* in 1910 (C); Pine-Grove, *Hansen* 1157, in part (C); Calaveras Co., near Harmon Peak, *Davy* 1407 (C); Mariposa Co., Benton Mills, *Congdon* in 1892, in part (C); Mariposa Valley, *Congdon* in 1897 (C); Sherlock's, *Congdon* in 1898 (C); Mariposa, *Congdon* in 1897 (S); Lewis, *Congdon* in 1896 (G); Mormon Bar, *Congdon* in 1896 (G); without locality, *Fremont p.p.p.* in 1846, cited as typical material *G. hispidula* (G), *Rattan* 32 (G), *Pratten* (G), *Mrs. Austin* in 1896 (C).

The identity of *Oenothera arcuata* Kellogg, Proc. Cal. Acad. 1:58. 1854–57, is not clear. The description more nearly fits *G. amoena* than anything else. As original material does not seem to be extant, there is no way of checking this. It is not certain therefore that JEPSON'S *Godetia arcuata* is the same concept as KELLOGG'S *Oenothera arcuata*. I have compared material cited by JEPSON as *G. arcuata* with type material of *G. hispidula* and of *G. hansenii*, and regard them as identical. All have the long-beaked capsule and glandular pubescence. The annular swelling at top of ovary (which is the chief character JEPSON used to designate *G. hansenii*) is present in all

of them, and may or may not be conspicuous; in fact, part of WATSON'S material of *G. hispidula* (the *Pratten* specimen) has a more accentuated swelling than the type of *G. hansenii*. In all of them the inner ring of hairs on the hypanthium is borne well down toward the base.

This is the only species in the genus which has glandular pubescence, and this character is of value in distinguishing *G. hispidula* from *G. dudleyana* and *G. biloba*, which sometimes resemble it superficially.

8. **Godetia cylindrica** (Jepson) comb. nov.—*Godetia bottae* var. *cylindrica* Jepson, Univ. Cal. Pub. Bot. **2**:332. 1907.

Erect, slender, simple or branching in upper half; stems 1–5 dm. tall; leaf blades narrowly lanceolate to linear, 2–4 cm. long, 0.15–0.4 cm. wide, acute to rounded, petioles 0.3–1.5 cm. long; inflorescence strigillose; buds nodding, slender, 1–2.5 cm. long, acuminate; hypanthium slender, 1.5–6 mm. long, green to lavender on outside, purple inside, with inner ring of hairs one-third to three-fourths way from base; calyx lobes green tinged with purple, to purple, 1–1.5 cm. long, united in anthesis, the tips not free in bud; petals lavender in upper half, shading to yellow-white, base purple, occasionally lavender or even white, usually marked with small purple dots, cuneate to broadly obovate, 0.8–2.6 cm. long, 0.7–2.3 cm. wide, narrowed at base but not forming a true claw, broadly obtuse or rounded to truncate at apex, the margin entire or slightly incised; filaments flattened, unequal, 2–6 mm. long, lavender; anthers subequal, 4–6 mm. long, yellow to lavender; style equaling or slightly exceeding longer stamens; stigma lobes narrowly ovate, 2–2.5 mm. long and one-third as wide, white to purple; capsule linear, 1.5–4 cm. long, 0.1–0.2 cm. wide, sessile or with pedicel as much as 4 mm. long, tapering to a pronounced beak 2–6 mm. long, 8-ribbed, the ribs alternately heavy and light, easily seen in young capsules, in older specimens and in dried material the capsules appear perfectly smooth and terete, or occasionally quadrilateral; seeds about 1 mm. long, dark brown, cresting not very prominent.

Type locality, Wortham Creek, near Alcalde, Fresno Co., California.

Representative material, CALIFORNIA: Los Angeles Co., Newhall Tunnel, *C. L. Hitchcock* 1 (P); Bouquet Canyon, *Munz* 6926 (P); 5 mi. W. of

Elizabeth Lake, *C. L. Hitchcock* 55 (P); 1½ mi. S. of Lebec, *C. L. Hitchcock* 44 (P); Kern Co., vicinity of Fort Tejon, *Parish* 1899 (G,S), *Hall* 6279 (C,P); Keene, *Feudge* 1174 (P), *Jones* in 1903 (P); Bakersfield, *Davy* 1713 (C,P); Caliente, *Coville* and *Funston* 1099 (C,S), *K. Brandegee* in 1905 (C); Lower Kern River Canyon, *Abrams* 11969 (P,S); Blue Mt., *Hall* and *Babcock* 5007 (C,P); Ventura Co., Hopper Creek Canyon, *C. L. Hitchcock* 43 (P); Santa Barbara Co., Orcutt, *Jones* in 1926 (P); Gaviota Pass, *C. L. Hitchcock* 2 (P); San Luis Obispo Co., Arroyo Grande, *Cook* in 1895 (C); Cuesta Pass, *C. L. Hitchcock* 6 (P); Santa Margarita, *Mrs. Summers* (C); southern part of San Luis Obispo Co., *Mrs. Summers* 329 (C); Paso Robles, *K. Brandegee* in 1911 (C), *Benjamin Cobb* 16 (C); Fresno Co., King's River, *Duncan* in 1923 (S); Tulare Co., Kaweah River basin, *Hopping* in 1901 (C).

This species shows considerable variation between the northern and southern forms. In its extreme northern range, toward the coast, the flowers have a shortened hypanthium, with the ring of hairs close to the summit, so that it is hard to tell it from *Godetia bottae* var. *typica*, except by the markings of the petals, the 8-ribbed, linear capsule, and narrow leaves. The following numbers are of this nature: San Luis Obispo Co., Templeton, *Wiggins* 2083 (S), *Sweet* in 1919 (S); Monterey Co., between King's City and Jolon, *K. Brandegee* in 1908 (C,G); Santa Lucia Mts., *Dudley* in 1901 (S). In general, it might be said that *G. bottae* as a species is coastal, while *G. cylindrica* is found usually toward the interior. In its southern range, *G. cylindrica* need not be mistaken for either *G. bottae* or *G. dudleyana*, because of the extremely narrow leaves, linear 8-ribbed capsules, coloration of petals, and, above all, by the slender, elongate hypanthium with the ring of hairs inside well down toward the base. In dried material the capsule usually appears quadrilateral or terete and unribbed, but in living material the ribs are as conspicuous as they are in *G. dudleyana* or in *G. viminea*.

9. GODETIA BOTTAE Spach, Nouv. Ann. Mus. Par. III, 4:393. 1835.

Erect, simple, or branching from base; stems 1.5–8 dm. tall; leaf blades linear to lanceolate, 2–7 cm. long, 0.2–1.5 cm. broad, acute to rounded, petioles 0.3–1 cm. long; inflorescence strigillose; buds drooping, 1–2.5 cm. long, slender to thick, acuminate or merely acute; hypanthium short and broad, 1–4 mm. long, inner ring of hairs borne just below summit, about four-fifths of way from base; calyx lobes lavender to green, 1–2 cm. long, united in anthesis, or

reflexed in pairs, tips not free in bud; petals lavender, sometimes lighter toward base, with or without tiny purple dots, cuneate-obovate, 1–3.5 cm. long, 1–3 cm. wide, retuse to obtusely pointed at apex, the margin more or less retuse, rather abruptly narrowed at base to a claw 0.5–1 mm. long; filaments flattened, unequal, 4–10 mm. long, short ones about two-thirds length of long ones; anthers subequal, 4–8 mm. long, yellow or lavender; style equaling or slightly exceeding longer stamens; stigma lobes white to purple, lobes 2 mm. long, or a little less, and one-third as broad; ovaries often canescent and reflexed when young; capsule elongate, 1.5–5 cm. long, 0.2–0.3 cm. thick, terete with no ribbing showing when young, but becoming square in cross-section at maturity and in dried material, at which time a median nerve is sometimes apparent on each face, beakless or with beak 1–4 mm. long, pedicel 0.2–3 cm. long; seeds dark brown, 1 mm. long.

Key to varieties

A. Leaves 0.2–0.4 cm. wide; calyx lobes usually rose tinted. In California from Gaviota Pass, Santa Barbara Co., northward to Monterey Co., along the coast.....9*a*. *G. bottae* var. *typica*

A. Leaves 0.4–1.5 cm. wide; calyx lobes usually green. Gaviota Pass to Orange Co., coastal.....9*b*. *G. bottae* var. *deflexa*

9*a*. GODETIA BOTTAE var. **typica,** nom. nov.—*Godetia bottae* Spach *loc. cit.;* Jepson, Univ. Cal. Pub. Bot. **2**:330. 1907; *Oenothera bottae* T. and G. Fl. N. Amer. **1**:505. 1840; Watson, Proc. Am. Acad. **8**:599. 1873; Leveille Monog. Onoth. 270. 1908, in small part, according to specimens cited; *Oe. godetia* Steud. Nom. ed. II, **2**:206. 1841.

Calyx lobes usually rose-colored; leaves narrow, 1.5–4 cm. long, 0.2–0.4 cm. wide; petals 1.2–2.5 cm. long, 1–2 cm. wide; young ovaries erect or deflexed, rather densely pubescent but not silvery.

Type locality, Monterey, California.

Representative material, CALIFORNIA: Monterey Co., Carmel Bay, *Heller* 6807 (G,S), *Heller* 4782 (C,P); Pacific Grove, *Heller* 6757 (C,G,P,S); Seaside, *Eastwood* 135 (G); Monterey, *Botta* in 1829, type material (G), *Guirardo* 701 (G), *Parry* (G); Santa Lucia Mts., *Dudley* in 1903 (S); Bardino, *Elmer* 4645 (C,P,S); near Monterey, *K. Brandegee* in 1908 (G,P,S); Monterey, *C. L. Hitchcock* 10 (P); San Luis Obispo Co., San Luis Obispo, *Palmer* 145 (C,G); Paso Robles, *Barber* in 1899 (C); California, *Hartweg* 1729 (G); *Brewer* 701 (G).

9*b*. GODETIA BOTTAE var. **deflexa** (Jepson) comb. nov.—*Godetia deflexa* Jepson, Univ. Cal. Pub. Bot. **2**:332. 1907.

Sepals usually green, seldom rose-tinted; leaves wide, 2–7 cm. long, 0.4–1.5 cm. wide; petals 1.6–3.5 cm. long, 1.5–3 cm. wide; young ovaries deflexed, silvery-canescent; plants larger and more robust than in the typical variety.

Type locality, "sandy plains of Los Angeles."

Representative material, CALIFORNIA: Santa Barbara Co., Gaviota, *Elmer* 3848 (C,G,S,P); Surf, *K. Brandegee* in 1909 (C); Los Angeles Co., Ravenna, *Craig* 495 (P); Santa Monica Mts., Sepulveda Canyon, *Abrams* 2553 (C,G,S,P), Cold Water Canyon, *Munz* and *Harwood* 3927 (P,S), Beverly Hills, *C. L. Hitchcock* 50 (P); Mt. Lowe, *Grant* 6666 (C,S); San Gabriel Canyon, *Eastwood* 8958 (G); Elysian Park, *Brandegee* and *Braunton* 124 (C,G,P,S); San Dimas Canyon, *C. L. Hitchcock* 51 (P); San Bernardino Co., Santa Ana River Canyon, *Munz, Street, Williams* 2647 (P,S), *C. L. Hitchcock* 49 (P). The following approach the typical variety, the leaves being fairly narrow and young ovaries pubescent: Santa Barbara Co., Lompoc, *Hoffmann* in 1927 (SB); Ventura Co., Red Reef Canyon, Topatopa Mts., *Abrams* and *McGregor* 132 (G,P,S); Conejo Grade, *Abrams* 6550 (S); without locality, hills bordering the Mohave Desert, *Pringle* in 1882 (G); Coast Hills, *Lemmon* 247 (G); Santa Barbara Co., *Torrey* 110 (G).

I have seen a photograph of the type of *G. deflexa* and consider it exactly like the collection from Gaviota, *Elmer* 3848, which JEPSON says is perhaps the same as *Cobb's* collection (the type). All of the material south of Gaviota Pass is considered to be *G. deflexa*. I do not, however, consider *G. deflexa* specifically distinct from *G. bottae*. Both have terete, smooth capsules when immature, and quadrilateral, nerved capsules when dry. They both may have the ovaries deflexed before anthesis, although the var. *deflexa* shows this tendency more often than the var. *typica*. Aside from the fact that the var. *deflexa* is the more robust plant and has wider leaves, there is little observable difference between the two.

10. GODETIA DUDLEYANA Abrams Fl. L. A. and Vic. 267. 1904.—*Godetia dudleyana* Jepson, Univ. Cal. Pub. Bot. **2**:333. 1907; *Clarkia dudleyana* Macbr., Contr. Gray Herb. n. ser. **56**:54. 1918; *G. bottae* var. *usitata* Jepson, Univ. Cal. Pub. Bot. **2**:332. 1907; *G. jucunda* Jepson, *loc. cit.* 334.

Erect, usually branching from middle, occasionally simple; stems

1.5–7 dm. tall; leaf blades narrowly lanceolate to spatulate, 2–5 cm. long, 0.3–1.1 cm. wide, acute to rounded, with petioles 0.3–1.2 cm. long, finely pubescent; inflorescence strigillose; buds drooping, slender, 1–2 cm. long; hypanthium short, 1–4 mm. long, lavender to green within and without, ring of hairs within, at, or near summit; calyx lobes 0.6–1.5 cm. long, lavender, united in anthesis, the tips not free in bud; petals cuneate, pink to deep magenta shading to white at base, usually with crimson or purple dots in lower portion, 1–3 cm. long, 0.7–2 cm. wide, truncate to rounded at apex, the margin entire to retuse, tapering uniformly to a short claw 0.5–2 mm. long; filaments filiform, subequal, 4–8 mm. long; anthers subequal, 5–7 mm. long, those opposite petals lavender at base, yellow toward tip, dehiscing first, alternate ones lavender, or all anthers yellow; style equaling longer stamens or exceeding them by as much as 3 mm.; stigma lobes 1–2 mm. long, one-third to one-half as broad, yellow to lavender; capsule slender, 1–3 cm. long, 0.1–0.3 cm. thick, beakless or tapering to a beak, 1–4 mm. long, rounded at base, usually sessile, or with pedicel 1–5 mm. long, 8-ribbed, terete, in dried material often appearing quadrilateral and with ribbing somewhat obscure; seeds about 1 mm. long, dark brown, cresting minute.

Type locality, Little Santa Anita Canyon, San Gabriel Mts., California.

Representative material, CALIFORNIA: Riverside Co., San Jacinto Mts., *Hall* 2265 (C,P); San Bernardino Co., Bluff Lake, *Williams* (C); San Bernardino, *Parish* 5054 (P), *Parish* 3672, type *G. bottae* var. *usitata* (C,G); Redlands Hills, *Greata* 536 (C); Los Angeles Co., Evey's Canyon, near Claremont, *C. L. Hitchcock* 45 (P,G); San Dimas Canyon, *C. L. Hitchcock* 46 (P); Puddingstone Canyon, San Dimas, *Munz* 10814 (P); Wilson's Trail near Santa Anita Canyon, *Abrams* 2625, type collection (C,G,S); Verdugo Canyon, *Macbride* and *Payson* 756 (G); Kern Co., Poso Creek Valley, *Dudley* 564 (S); Inyo Co., Owen's Valley, *Austin* 387 (C); Tulare Co., Sequoia Nat. Forest, *Dudley* 1796 (S); Old Colony Mill, *K. Brandegee* in 1907 (C,P); valley of Kaweah R., *Coville* and *Funston* 1320 (C); Middle Tule R., *Purpus* 5036 (G); Fresno Co., Converse Basin, *Dudley* 3400 (S); between Pine Ridge and Toll House, *K. Brandegee* in 1910 (C); Madera Co., Raymond, *Cummings* in 1896 (G); Mariposa Co., Mariposa, *Congdon* in 1896 (G,S); Merced Canyon, *Abrams* 4681 (C,G,P,S); Tuolumne Co., Tuolumne River, *Blasdale* in 1895 (C). The following collections are peculiar in that the capsules are unusually heavily ribbed: San Antonio Canyon, near Claremont, *Baker* 3665 (G,P); Los Angeles Co., Azusa, *Nevin* 32a (G); Tulare Co., So. Fork Kaweah R., *Eastwood* 4495 (G,P).

This species has been confused with *G. bottae*, *G. cylindrica*, and *G. hispidula*. It is distinguished from *G. bottae* by the slender, 8-ribbed capsule and filiform filaments, *G. bottae* having a smooth capsule and flattened filaments. In fresh material *G. dudleyana* has a round capsule with eight conspicuous ribs. When dried its capsule often appears square in cross-section and the ribs are not easily seen. *G. dudleyana* is readily distinguished from *G. cylindrica* and *G. hispidula* by the position of the ring of hairs on the inside of the hypanthium. The last two species bear this ring near the middle of the tube, while *G. dudleyana* has it at the top. Furthermore, the red ring at the base of the petals in *G. cylindrica* is distinctive and the glandular pubescence of *G. hispidula* easily separates it.

Comparison of type material of *G. dudleyana* with *Parish* 3672, the type of *Godetia bottae* var. *usitata*, shows that they are identical. Furthermore, there is no difference between the material from Southern California and that of the Sierras; therefore *G. jucunda*, a name which JEPSON proposed for the Sierran plants, must be treated as a synonym. The lobing of the stigma in *G. dudleyana* is worthy of special note, varying considerably. Variation is found in the type collection, and often on the same plant different flowers show a wide range in the length of the lobes.

11. GODETIA EPILOBIOIDES (Nutt.) S. Wats., Bot. Calif. **1**:231. 1876.—*G. epilobioides* Jepson, Univ. Cal. Pub. Bot. **2**:343. 1907; *Oenothera epilobioides* Nutt. *in* T. and G. Fl. N. Amer. **1**:511. 1840; Wats., Proc. Am. Acad. **8**:599. 1873; Leveille Monog. Onoth. 262. 1908; *Sphaerostigma epilobioides* Walp. Rep. **2**:78. 1843; *Clarkia epilobioides* Nels. and Macbr., BOT. GAZ. **65**:60. 1918; *C. modesta* Jepson Man. Fl. Pl. Cal. 673. 1925.

Erect, simple to diffusely branching entire length but usually sparingly branched from near middle; stems 1.5–4.5(–6.5) dm. tall; leaf blades linear to broadly lanceolate or spatulate, 1–4 cm. long, 0.2–0.6 cm. broad, acute to blunt, petiole 2–6(–9) mm. long; inflorescence strigillose; buds nodding, 5–8 mm. long; hypanthium very short, 1–1.5 mm. long, inner ring of hairs near summit; calyx lobes united in anthesis, 3–5 mm. long, tips not free in bud; petals obovate, 6–11 mm. long, 4–8 mm. wide, commonly whitish although sometimes pink or lavender, this color often accentuated when dried,

with or without purple spots near base, rounded at apex, tapering to a very short claw; filaments unequal, 2–6 mm. long, filiform, short ones about two-thirds length of long ones; anthers subequal, 1–1.5 mm. long, yellow or white; style about equaling long stamens; stigma lobes very short, not over 0.5 mm. long, yellow; capsule linear, 1.5–3 cm. long, 0.1–0.15 cm. thick, rather densely strigillose when young, sparsely so in age, weakly 8-ribbed, appearing quadrilateral in pressed specimens, beak 0.5–2 mm. long, pedicel 1–10 mm. long; seeds dark brown, 0.5 mm. long and two-fifths as broad, cellular-puberulent, cresting minute.

Type locality, San Diego, California.

Representative material, CALIFORNIA: San Diego Co., San Diego, *Nuttall*, type collection (G); Mission Hills, *Abrams* 3442 (G,P,S); near Fallbrook, *Abrams* 3331 (C,G,P,S); Tecate Mt., *Munz* 8005, petals yellow to lavender (P); Ramona, *K. Brandegee* in 1894 (C); Riverside Co., Glen Ivy, *Munz* 5052 (P); San Jacinto Mts., *Mrs. Gregory* in 1892 (C); Banning, *Gilman* 23 (C); Box Springs Mt., *Hall* 273 (C); San Bernardino Co., San Bernardino, *Parish* in 1901 (S); Santa Ana River Canyon, *Munz, Street, Williams* 9439 (P); Arrowhead Hot Springs, *Grant* in 1906 (S); Los Angeles Co., Topango Canyon, *Munz* and *Harwood* 3984 (P); Santa Monica Mts., Santa Inez Canyon, *C. L. Hitchcock* 48 (P); Pasadena, *Allen* in 1895 (G); Glendale to Burbank, *Braunton* 887 (C,S); Claremont, *Baker* 4735 (C,P); San Gabriel Canyon, *Munz* 9439 (P); Santa Catalina Island, *K. Brandegee* (C); Orange Co., Laguna, *Munz* 2175 (P); Ventura Co., Casitas Pass, *Hall* 3138 (C,P,S); Santa Barbara Co., Santa Cruz Island, *Hoffmann* in 1925 (SB); San Marcos Road, Painted Cave Ranch, *Eastwood* 43 (C,G); San Luis Obispo Co., Arroyo Grande, *King* in 1895 (C); Monterey Co., Santa Lucia Mts., *Plaskett* 134 (G); Tassajara, *Dudley* in 1901 (S); San Benito Co., between Emmet and Panoche Pass, *Abrams* and *Borthwick* 7886 (S); New Idria, *Abrams* and *Borthwick* 7970, flowers pink (S); Hernandez, *Lathrop* in 1903 (S); Fresno Co., below Huntington Lake, *A. L. Grant* 1160 (S); Santa Clara Co., near Bald Peak, *Dudley* 4198, petals pale lavender (S); Contra Costa Co., Antioch, *K. Brandegee* (S); Stanislaus Co., Knight's Landing, *Bigelow* in 1853–4, petals pink (G); Mariposa Co., Lewis, *Congdon* in 1895, petals lavender (S); Mormon Bar, *Congdon* in 1883 (G); LOWER CALIFORNIA: Guadalupe Mts., *Orcutt* 858 (G); San Requis, *T. S. Brandegee* in 1889 (C).

The type of *Clarkia modesta*, which was kindly lent by JEPSON, matches in all respects other material from Central California, such as *Heller's* 11458 from 10 miles east of Alder Springs, Glenn Co. (G,S), which I consider to be *G. epilobioides* (*cf.* Munz and Hitchcock, Bull. Torr. Club. **56**:197. 1929).

12. GODETIA BILOBA (Durand) S. Wats., Bot. Calif. 1:231. 1876. —*G. biloba* Jepson, Univ. Cal. Pub. Bot. 2:333. 1907; *Oenothera biloba* Durand, Jour. Acad. Nat. Sci. Phila. II, 3:87. 1855; S. Wats., Proc. Am. Acad. 8:599. 1873; *Clarkia biloba* Nels. and Macbr., BOT. GAZ. 65:60. 1918; *Oe. prismatica* var. *biloba* Leveille Monog. Onoth. 264. 1908; *G. dudleyana* f. *brandegeae* Jepson, Univ. Cal. Pub. Bot. 2:334. 1907.

Erect, simple or branching above or from base; stems 2–7.5 dm. tall; leaves elliptic to linear-elliptic, 1–5 cm. long, 0.1–0.5 cm. wide, acute, petiole 0.5–1.5 cm. long; inflorescence strigillose; buds drooping, 1–2 cm. long, with slender point 1–2 mm. long; hypanthium 1.5–5 mm. long, usually tinged with red, tips not free in bud; petals magenta, with or without purple dots near base, narrowly to broadly cuneate, 1–2.3 cm. long, 0.4–1.8 cm. wide, with claw 1–2 mm. long, the apex exceedingly variable, from slightly retuse to deeply so, the petal then forming a deep V with the two lobes occasionally in turn slightly divided; filaments subequal, 4–8 mm. long, subfiliform; anthers 4–7 mm. long, yellow to lavender; style equal to or slightly exceeding longer stamens; stigma rather shallowly lobed, lobes 1–1.5 mm. long and half as broad, lavender; capsule rather short, 1–2.5 cm. long, 0.15–0.2 cm. thick, borne on pedicels 0.1–1 cm. long, beakless or short beaked, 8-ribbed, terete but in dried material often apparently quadrilateral; seeds 1 mm. long, dark brown, cresting minute.

Type locality, Nevada City, California.

Representative material, CALIFORNIA: Contra Costa Co., Port Costa, *K. Brandegee* in 1905 (C), *C. L. Hitchcock* 15 (P); between Port Costa and Martinez, *K. Brandegee* in 1907 (C), *C. L. Hitchcock* 13 (P); Mt. Diablo, *Elmer* 4319 (C,P,S); Mariposa Co., Mariposa, *Congdon* 187 (S); Mt. Bullion, Yosemite National Park, *Bolander* and *Rattan* 6364 (C,G); Tuolumne Co., Table Mt., *A. L. Grant* in 1915 (S); Rawhide Hill, *Mrs. Williamson* 68 (P,S); Groveland, *Abrams* 4708 (G,P,S); Calaveras Co., Angel's Camp, *Davy* 14843 (C); near Mokelumne Hill, *Rattan* in 1885 (G,S); Amador Co., Near Jackson, *Mullikin* 108 (C,P,S), *C. L. Hitchcock* 29 (P); between Sutter Creek and Pine Grove, *C. L. Hitchcock* 33 (P); El Dorado Co., Sweetwater, *K. Brandegee* in 1907 (G,P); Nashville, *Rixford* in 1902 (C,G); Placer Co., Colfax, *Jones* 3340 (P,S), *Eastwood* 619 (G); 4 mi. E. of Colfax, *Heller* 12746 (G,S); Nevada Co., near Wolf Creek, *Eastwood* 3437 (G); California, *ex Durand* 1855, probably type material (G).

Some of the Sierran plants of *G. biloba* approach *G. dudleyana* quite closely, the petals being very shallowly retuse. Such collections as those from Nevada Co., Bear River, *Hall* 10155 (C,P); Mariposa Grove, *King* in 1907 (C); and El Dorado Co., Simpson's Ranch, Sweetwater Creek, *K. Brandegee* on May 29, 1907, type of *G. dudleyana* f. *brandegeae* (C), are of this nature. In such cases there are several characters that help to distinguish the two. The capsule in *G. dudleyana* is sessile or very short pedicelled, while in *G. biloba* the pedicel may be as much as 1 cm. long. The stigma lobes are shorter in *G. biloba*, and the bud is more nearly ellipsoid and has a longer point than that of *G. dudleyana*.

Doubtful or excluded species

1. OENOTHERA HUMILIS Donn Cat. Hort. Cantab. ed. I, 41. 1796.—The only reference to this plant which I can find is a footnote upon the page on which *Oe. purpurea* is described (B. M. 352, Bot. Mag. 10:*t.* 352. 1796). Mr. T. A. SPRAGUE of Kew kindly supplied the following information:

"We do not have the 1st edition of Donn's Hort. Cantab. at Kew, nor is it represented in the British Museum (Natural History). In the Kew Herbarium, however, there is a letter from the late Dr. JACKSON according to which the publication of *Oenothera humilis* was as follows: 'humilis. W. Coast N. Am. 1791. July. H. ⊙.' (Donn Hort. Cantab. ed. I, 47* (?): 1796.) In my opinion and in that of my colleagues the information accompanying each name in the Hort. Cantab. was not intended for a description and cannot be accepted as such. Roxburgh's Hortus Bengalensis is a parallel case (see Kew Bull., 1925, pp. 311–315)."

2. OENOTHERA ROMANZOWII Ledeb. *ex* Hornem., Hort. Hafn. Suppl. 133. 1819.—This species is apparently known only from garden specimens, the description being drawn from plants grown from seeds collected by *Chamisso* on the northwest coast. In the Gray Herbarium there are two sheets, one from the "Jardin des plantes, le 3 aout 1837," and one labeled "Cult. Sartwell, e sem. Hort. Soc. Lond. 1833," which I take to be typical material. These plants resemble the material of *Oe. tenella* from South America more closely than anything else which I have seen. In Mrs. BRANDEGEE'S notes is

this memorandum: "Lindley, in Hort. Trans. VI. 94 (1827) says: 'It is not improbable that the *Oe. romanzowii* of Hornemann and the Continental Gardens may be the same as *Oe. tenella*, but the *Oe. romanzowii* published in the Botanical Register, *t.* 562 is not different from *Oe. purpurea*. I had many opportunities of observing the plant which was in 1821 called *romanzovii*, both in the Chelsea Garden, and in Mr. KENT'S garden at Clapton, whence the figure for the Botanical Register was obtained, and I have no difficulty in declaring that it was scarcely distinguishable even as a variety from *Oe. purpurea*.' "

The plate in the Botanical Register does resemble *G. purpurea* very closely, but the capsules in the illustration are much larger and thicker than in the two collections which I have seen.

3. GODETIA NIVERTIANA Goujon in Rev. Horticole 431. 1872.—This is a *nomen nudum*, published in a horticultural journal, without diagnosis.

4. GODETIA PULCHERRIMA Greene, Pittonia **2**:217. 1891.—This would seem from its description to be *G. bottae* var. *deflexa*. The type from Los Angeles Co., *Mrs. W. F. Wheeler*, I am unable to locate. *Mr. Parish's* n. 1899 from Fort Tejon, which was "apparently about the same," is undoubtedly *G. cylindrica*, but it certainly does not have "petals . . . . lilac and streaked with white veins above, whitish at the base," nor a distinctly pedicelled capsule. Apparently the two collections are not conspecific and because of this ambiguity the name is rejected.

5. GODETIA DELICATA Abrams, Bull. Torr. Bot. Club **32**:539. 1905 is to be referred to Clarkia (*cf.* Munz and Hitchcock, Bull. Torr. Club **56**:188. 1929).

6. GODETIA LATIFOLIA Nels. and Ken., Proc. Biol. Soc. Wash. **19**:156. 1906; type from Sierra Co., Sierra Valley, California, *Miss Helen Hamlin*, July, 1904. Through the kindness of Professor FLEMING of the University of Nevada, this type has been made available. It is typical *Clarkia rhomboidea*.

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NEW OR OTHERWISE NOTEWORTHY COMPOSITAE. IV

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 403

EARL EDWARD SHERFF

Bidens distans sp. nov.—Frutex erectus, glaber, ramosus, verisimiliter 6–9 dm. altus, caule subtereti, glaucescenti. Folia petiolata petiolis tenuibus 3–4.5 cm. longis, petiolo adjecto 9–16 cm. longa, nunc pinnatim 3–5-partita foliolis lanceolatis serratis dentibus acriter mucronatis, apice acutis sed parce acuminatis; nunc indivisa lamina lanceolata ±11.5 cm. longa et ±4 cm. lata, unico latere circ. 16–20 dentibus munita. Capitula paniculato-corymbosa, numerosa, subdense disposita (distantia) pedicellis tenuibus plerumque 1–2 cm. longis, radiata, pansa ad anthesin 1.5–2 cm. lata et circ. 6–7 mm. alta. Involucri bracteae exteriores 4–6, oblongo-lineares, obtusae, minimae (1–2 mm. longae), quam interiores lanceolatae multo minores. Flores ligulati plerumque 5, ligula anguste oblongi, flavi, apice plus minusve denticulati, 8–12 mm. longi. Achaenia recta vel vix curvata, anguste linearia, plana, exalata, atra vel ad apicem brunnea, unaquaque facierum circ. 4-sulcata, corpore 8–11.5 mm. longa et 1.1–1.7 mm. lata, facie marginibusque glabra, apice interdum paucisetosa, sub apice irregulariter biaristata aristis erectis et retrosum barbatis, usque ad 1 (rarius –3) mm. longis.

Specimens examined: *Charles N. Forbes* 148*L*, "at Gay's," on mountains near Koele,[1] north of Maneke Bay, Isl. Lanai, Hawaiian Isls., June, 1918 (type, Herb. Field Mus.: cotype, Herb. Bishop Mus.); *G. C. Munro*, Kapano, Isl. Lanai, Jul. 28, 1915 (Herb. Field Mus.).

Differs from *B. hawaiensis* Gray in its smaller and more numerous heads, minute exterior involucral bracts, fewer rays, mostly divided leaves, etc. Differs from *B. micrantha* Gaud. in its more open inflorescence, dullish-black not truly shining achenes, glaucescent stem, etc.

BIDENS TENERA var. **paucidentata** (O. E. Schulz) comb. nov.;

[1] Spelled Koala upon United States Geological Survey map. But a Mrs. GREENLAND (née GAY) informed *H. Wiebke* (*fide O. Degeneri in litt.*, Feb. 9, 1928) that the name is spelled locally Koele, not Koala.

B. ekmanii et var. *paucidentata* O. E. Schulz *in* Urban, Repert. Spec. Nov. Regn. Veg. **26**:111. 1929; *B. tenera* var. *tetracera* Sherff, Bot. Gaz. **88**:293. 1929.—My *Bidens tenera* var. *tetracera*, published in November, 1929, was found to have been antedated several months by the equivalent *B. ekmanii* O. E. Schulz and its so-called var. *paucidentata*, both of Cuba. The type specimens of *B. ekmanii* and its var. *paucidentata* are now before me (through the kindness of Dr. Gunnar Samuelsson, Director of the Botanical Section of the Natural History *Reichsmuseum* of Stockholm). They differ mutually to an insignificant extent. Nor are they separable from the South American specimens described by me for *B. tenera* var. *tetracera*. The varietal name *paucidentata* accordingly is here taken up as required by the Vienna Code.

Bidens townsendii sp. nov.—Herba annua, erecta, subsimplex, 8–10 dm. alta, caule acriter tetragono glabra. Folia tenuiter petiolata petiolis usque ad 2.5 cm. longis, petiolo adjecto circ. 8–10 cm. longa, 1–2-pinnata, segmentis primariis lateralibus circ. 2 jugis, superioribus simplicibus inferioribus saepius tripartitis, segmentis lanceolatis membranaceis acriter serratis adpresse setosis, apice acuminatis, sub medio circ. 0.7–1.7 cm. latis. Capitula pauca, tenuiter pedunculata pedunculis 3–6 cm. longis, subradiata, pansa ad anthesin ±1.2 cm. lata et circ. 6 mm. alta. Involucri bracteae exteriores 8–12, anguste lineares, superne non spathulato-dilatatae, apice acerrimo induratae, 3–6 mm. longae, interiores lanceolatae subaequales. Flores ligulati ±5, rudimentarii, ligula obovati, albidi vel subrosacei, plus minusve perspicue striati, circ. 4 mm. longi. Achaenia exalata, exteriora clavata, obcompresso-tetragona, rubido-nigra, hinc inde saepe sparsim setosa, corpore circ. 4–4.5 mm. longa et 1–1.2 mm. lata, apice calva vel biaristata, aristis stramineis retrorsum hamosis circ. 0.5 mm. longis; interiora tenuiter linearia, corpore usque ad 11 mm. longa, nigra, supra marginaliter setosa, biaristata aristis stramineis retrorsum hamosis 1–1.5 mm. longis.

Specimens examined: *C. H. T. Townsend* and *C. M. Barber* 415, near Chuichupa in the Sierra Madres, State of Chihuahua, Mexico, Sept. 6, 1899 (type, Herb. N.Y. Bot. Gard.).

A close ally of the South American *Bidens subalternans* DC., the Old World *B. biternata* (Lour.) Merr. & Sherff, and the cosmopolitan

B. pilosa L. From the last it is readily distinguished by the lack of apical dilation in the exterior involucral bracts.[2]

BIDENS HAWAIENSIS **conglutinata** Degener and Sherff var. nov.—A specie achaeniorum aristis omnino summo corpori conglutinatis non distantibus, erectis tenuibus circ. 2–3 mm. longis differt.

Specimens examined: *Antone Borges* 3798, on dry lava flow of 1840, southeast of Pahoa, easternmost part of Isl. of Hawaii, Hawaiian Isls., Nov. 18, 1929 (type, Herb. Field Mus., 2 sheets: cotypes, Herb. Kew; Herb. Berl.; Herb. Gray).

Bidens malmei sp. nov.—Herba annua, erecta, caule acriter tetragona, supra ramosa, 0.4–1 m. alta. Folia tenuiter petiolata petiolis usque ad ±4 cm. longis, petiolo adjecto 4–10 cm. longa, minutissime sparsimque pubescentia, ciliata, membranacea, primaria mediana subbipinnata, foliolis lateralibus 2–3-jugis, basalibus rursus 2–3-partitis, aliis indivisis, omnibus circumambitu ovatis circ. 2.5–3.5 cm. longis, crenato-dentatis, dentibus (saepe duplicibus) unico latere circ. 6–12; superiora minora, bipinnata vel etiam tripinnatisecta, segmentis plus minusve ovato-oblongis. Capitula laxe corymboideo-paniculata, tenuiter pedunculata pedunculis 5–17 cm. longis, subradiata, pansa ad anthesin circ. 6 mm. alta et aequaliter lata. Involucri basaliter hispidi bracteae exteriores 6–8, lineares, hispidae, apice subacutae, sub apice rarissime subdilatatae, 3–4 mm. longae; interiores lineari-lanceolatae, 5–7 mm. longae. Flores ligulati albidi rudimentarii, ligula ipsa tantum circ. 1–1.5 mm. longi plus minusve obcordati ac apice paucidentati. Achaenia linearia, nigra, tetragona, unaquaque facierum 2-sulcata, glabra vel aegre erecto-setosa, corpore 7–11 mm. longa et 0.5–0.7 mm. lata, apice exteriora 2–3-alia 4-aristata, aristis stramineis retrosum hamosis, 2–3 mm. longis.

Specimens examined: *Gust. O. A. Malme* 1456, near Menino Denso, Porto Alegro, State of Rio Grande do Sul, Brazil, March 3, 1902 (Herb. Mus. Bot. Stockholm, 2 type sheets).

Allied with *Bidens bipinnata* L., *B. duranginensis* Sherff, *B. gardneri* Baker, and *B. subalternans* DC.

Dahlia linearis sp. nov.—Caules tenues, ramosi, lignescentes, subglabrati, striati, ramorum internodiis circ. 5–6 cm. longis. Folia

[2] Duplicates of the type were widely distributed to herbaria under Prof. E. L. GREENE'S determination, *Bidens heterophylla* Ort. In the main, however, they lacked mature fruiting heads and were omitted in my mss.

opposita, tenuiter petiolata petiolis planis basi connatis ventraliter basaliterque brunneo-pilosis tantum 0.3–2.2 cm. longis, petiolo adjecto 5–8 cm. longa, 2–3-pinnata, segmentis ultimis linearibus (1–2 mm. latis), glabris vel hinc inde praecipue ad venas adpresso-hispidis, apice acuto submucronatis. Capitula subnumerosa, breviter tenuiterque pedunculata, radiata, pansa ad anthesin 4–6 cm. lata et 1.2–1.4 cm. alta. Involucri glabri bracteae exteriores 5–8, patentes, oblongo-lanceolatae, dorsaliter 4–5-lineatae, 5–7 mm. longae; interiores oblongo-lanceolatae vel oblongo-ovatae, adpressae, 1.3–1.6 cm. longae. Flores ligulati ± 7, rosacei, ligula anguste elliptico-obovati, apice mucronulati vel minutissime sed acerrime 2–4-denticulati, 2.2–3 cm. longi. Achaenia clavata, grisea vel atro-grisea, plana, exalata, unaquaque duarum facierum mediano-costata ac circ. 8–10-striata, rugosa, nunc aegre hispida nunc glabrata, 8.5–9 mm. longa et supra circ. 1.2 mm. infra circ. 0.5 mm. lata, apice saepius bidenticulata sed non vere aristata.

Specimens examined: *Brother Agniel* (*Bro. G. Arsène* distrib. no. 10286), alt. 1850 m., Querétaro, State of Querétaro, Mexico, 1910–1913 (type in Herb. Mo. Bot. Gard., herb. no. 841136).

Closest to *Dahlia dissecta* Wats., from which it differs in its more slender and more woody branches, its shorter internodes (which give a more compact habit), its very different leaves (petioles 0.3–2.2 cm. not mostly 3–6.5 cm. long, at their very base densely brownish-pilose not glabrous or nearly so, ultimate segments 1–2 mm. not mostly 4–7 mm. wide, etc.), its more numerous and much shorter peduncles (4–7 cm. not 15–30 cm. long), its oblong-ovate not ovate-orbicular exterior involucral bracts, etc. The two small specimens of the type sheet are each a little more than 2 dm. long. One had 5 heads, the other 9 heads. The two apical teeth found on most of the achenes represent of course the aristae found so commonly in *Bidens*, *Coreopsis*, and *Cosmos*, but normally absent in *Dahlia*.[3]

Coreopsis heterolepis sp. nov.—Herba perennis, glabra, caule angulata, ramosa, dense foliosa, 3–6 dm. alta. Folia membranacea

[3] *Dahlia* material cultivated by Prof. J. B. S. NORTON at Hyattsville, Maryland, in 1926, "original source unknown," was found to have achenes biaristate, *the aristae naked, almost capilliform, and mostly 6–10 mm. long!* Prof. NORTON had already cultivated this peculiar form through three generations at the time of his sending me some ripened heads for study.

plus minusve dimorpha: basalia dense congregata, petiolata petiolis planis angustissime alatis usque ad 6 cm. longis, petiolo adjecto 8–12 cm. longa, indivisa spathulata vel oblonga apice obtusa, alia pinnata foliolis nunc linearibus nunc oblanceolatis nunc oblongis nunc rhomboideo-subovatis ac etiam 1–1.7 cm. latis, lateralibus saepius 1–2 jugis ac multo minoribus; caulina numerosissima, petiolata petiolis anguste marginatis marginis basi setis multiloculatis sparsim positis obsitis circ. 1–2.5 cm. longis petiolo adjecto circ. 6–10 cm. longa, plerumque pinnata, foliolis anguste linearibus, 2–8 cm. longis et 0.3–2.5 mm. latis, apice subacutis, lateralibus 1–2 jugis. Capitula tenuissime pedunculata pedunculis 1–2 dm. longis, radiata, pansa ad anthesin 3–4 cm. lata et 5–7 mm. alta. Involucri glabri vel subglabri bracteae exteriores angustissime lineares, saepius patentes, apice acutae, 5–11 mm. longae; interiores ovato-lanceolatae nunc breviores nunc longiores. Flores ligulati circ. 8, omnino flavi, ligula cuneato-obovati, apice obtuse 4-dentati, circ. 1.5–1.8 cm. longi. Paleae superne capillares, circ. 4–5 mm. longae. Disci florum stigmata caudato-elongata. Achaenia minima, plano-convexa, corpore nigro oblongo vel oblongo-ovato ipso tantum circ. 1.3–1.7 mm. longa et circ. 1–1.5 mm. lata, faciebus levia vel papillato-rugosa (ventrali apicaliter basaliterque saepius callosa), marginibus anguste alata alis rubris circ. 0.2–0.4 mm. latis, apice minutissime 2-squamellata squamellis fimbriolatis.

Specimens examined: *Ernest Jesse Palmer* 6962*A*, dry, sandy bluffs, Heber Springs, Cleburne County, Arkansas, Oct. 30, 1914 (4 type sheets, Herb. Mo. Bot. Gard.).

Coreopsis debilis sp. nov.—Herba perennis, caulibus saepius 2–6, e radice lignescenti erectis, tenuissimis, angulatis, glabris, 3–6 dm. altis. Folia opposita, membranacea, petiolata petiolis tenuibus usque ad 2 cm. longis, lamina nunc indivisa linearia vel parce linearioblanceolata margine integra ciliataque apice vix acuta basim versus sensim angustata faciebus saepe aegre hispida petiolo adjecto 2–5 cm. longa et 1–5 mm. lata; nunc majora, petiolo saepe 3.5 cm. longo adjecto 7–9 cm. longa, aegre pinnata (raro etiam subbipinnata) segmentis lateralibus plerumque 1–2 jugis, quam terminali minoribus, linearibus vel subfiliformibus. Capitula pauca vel numerosa, tenuiter pedunculata pedunculis 1–2 (–3) cm. longis, radiata, pansa

ad anthesin circ. 2–2.5 cm. lata et circ. 7–9 mm. alta. Involucri saepius glabrati bracteae exteriores circ. 8, lineares lanceolataeve, apice acutae vel obtusae, margini ciliatae, basim versus saepe scariosae, 3–4 mm. longae; interiores lanceolatae vel ovato-lanceolatae, 7–8 mm. longae. Flores ligulati flavi, ligula cuneato-obovati, apice saepius 4-dentati dentibus acutis, circ. 1 cm. longi. Paleae lineares, superne angustissime elongatae. Stylorum (florum disci) rami terminaliter caudati. Achaenia obcompressa, tergo papillato-rugoso convexa, corpore ipso atro circ. 2 mm. longa et circ. 1 mm. lata, marginibus anguste alata, apice 2-squamellata squamellis fimbriolatis; facie ventrali glabra vel papillato-scabra, supra infraque valde callosa.

Specimens examined: *A. H. Curtiss*, Pensacola, Florida, summer of 1885 (Herb. N.Y. Bot. Gard.); *Charles Mohr*, dry, open, sandy hills etc., *eodem loco*, Jul. 4, 1874 (Herb. U.S. Nat., 2 sheets); *idem*, in woods, Cullman, Alabama, June 1, 1882 (Herb. Gray); *idem*, low, open places, Cullman, June, 1883 (Herb. U.S. Nat., 3 sheets); *idem*, dry hillsides, vicinity of Ashland, Bibb County, Alabama, June, 1883 (Herb. U.S. Nat.); *idem*, borders of woods and fields, dry openings, Mulberry River Valley, Blount County, Alabama, June 6, 1883 (Herb. U.S. Nat.); *idem*, sandy soil in open copses, Columbus, Mississippi, June 4, 1888 (Herb. U.S. Nat.); *idem*, dry, bald prairies, Gallion, Alabama, May 25, 1893 (Herb. U.S. Nat.); *Charles L. Pollard* and *William R. Maxon* 496, Lithonia, Georgia, Aug. 12, 1900 (Herb. N.Y. Bot. Gard.); *John Donnell Smith* 602, dry, sandy old fields along coast of Mississippi Sound, Harrison County, Mississippi, Sept. 15, 1885 (type, Herb. Field Mus.: cotype, Herb. Gray).

A species more closely related to *Coreopsis lanceolata* L. and *C. grandiflora* Hogg. *J. Donnell Smith* had determined his plant as *C. lanceolata* var. *angustifolia* Torr. & Gray. That variety, however, has a very different habit, the plants being less branched and the leaves being basally clustered and almost always simple. *Donnell Smith* had shown ASA GRAY his Mississippi material, and GRAY had called it "a peculiar form" of *C. lanceolata* L. *Mohr's* material from Pensacola, Florida, likewise had been seen by GRAY. Thus, one sheet bears a note stating: "Dr. GRAY remarks: 'I have nothing like this. I suppose it may be an altered, coast form of *C. lanceolata*. But it is very peculiar.' "[4] This same sheet has *Mohr's* first

[4] This note is written on the back of a card which, by strong transmitted light, is seen to have been *Donnell Smith's* regular herbarium label. This would seem to indicate that *Mohr* and his contemporary had studied their several specimens mutually and had regarded them as identical.

determination, *Coreopsis lanceolata* var. *angustifolia*, but this he had subsequently crossed out and replaced with *C. grandiflora*. His other foregoing specimens all had been labeled by him as *C. grandiflora*. This interpretation was retained by him in his Plant Life of Alabama (Contrib. U.S. Nat. Herb. **6**:805. 1901). From *C. grandiflora*, however, our plants differ in their more slender and wiry, less herbaceous stems, in the tendency for some entire stems to have minute, simple leaves (smaller than the simple leaves formed in *C. lanceolata*), and in the tiny achenes, which have the body proper about 2 mm. long and about 1 mm. wide, as against about 2.5 mm. long and about 1.4–1.8 mm. wide in *C. grandiflora*.[5]

COREOPSIS GRANDIFLORA **pilosa** var. nov.—A specie caulibus foliisque pubescentibus saepe etiam longe patenteque piloso-hispidis differt.

Specimens examined: *Stewardson Brown*, *N. L. Britton*, and *Peter Bisset* 2011, cultivated, Agricultural Station, Isl. Bermuda, May 22–June 6, 1914 (type, Herb. N.Y. Bot. Gard.); *John H. Kellogg*, cultivated, Missouri Botanical Garden, St. Louis, Missouri, May 23, 1911 (Herb. Mo. Bot. Gard.); *John K. Small*, alt. 700–1000 ft., between Alcovy River and No Business Creek in Oconee and Gwinett Counties, Georgia, Jul. 14, 1893 (Herb. U.S. Nat.).

C. grandiflora Hogg is typically glabrous. The two cultivated specimens examined have a very unique aspect because of their marked hispidity. In spontaneous material the hairs are shorter and less spreading.

COREOPSIS DELPHINIFOLIA Lam. Encycl. **2**:108. 1786; *C. discolor* Link Enum. Hort. Berol. **2**:353. 1822.—LINK's description of his own *C. discolor* ("Fol. subsessilibus ternatis foliolis linearibus acutis integerrimis. . . . .") would seem to indicate *C. major* var. *rigida* (Nutt.) Boynt. Recently I was very generously lent some specimens from the Museum of the Berlin Botanical Garden, and among these was a sheet of the original cultivated material of *C. discolor*. The plant has the uppermost leaves ternate as described by LINK, but the principal stem leaves each have several more segments than three and place LINK's plant at once with *C. delphinifolia* Lam.

[5] A similar or even more pronounced achenial difference separates *C. debilis* also from *C. lanceolata*. Furthermore, the achenes of *C. debilis* are narrowly winged (0.2–0.5 mm. wide) while those of *C. grandiflora* and *C. lanceolata* commonly have wings 1 mm. or so in width.

Coreopsis suaveolens sp. nov.—Frutex ramosus, verisimiliter 5–8 dm. altus, ramis subteretibus plerumque glabratis sed hac illac glutinosis odore *Covilleae divaricatae* (Cav.) Vail suaveolentibus. Folia opposita fasciculata, primaria 1.2–1.6 cm. longa, pinnatim 3–5-secta, plus minusve glutinosa, segmentis petiolis similibus vel rursus sectis, ultimis linearibus, glanduloso-hispidis, carnosis, apicaliter mucronatis, tantum 0.3–0.6 mm. latis. Capitula ramos superne nudos (pedunculos tenues) terminantia, solitaria, radiata, pansa ad anthesin ± 2.3 cm. lata et 7–9 mm. alta. Involucri hispidi bracteae exteriores circ. 8, oblongae vel late lanceolatae, obtusae, 3–5 (–7) mm. longae, quam interiores oblongo-lanceolatae circ. 8 mm. longae saepius dimidio breviores. Flores ligulati circ. 6, lutei, ligula oblongo-elliptici, apice integri vel (etiam profunde) bifidi, 7–11 mm. longi. Disci florum stigmata brevia, abrupte incrassata truncataque. Achaenia non visa. Habitu *C. fasciculatae* Wedd. valde similis.

Specimens examined: *Dr. E. Werdermann* 1114, alt. about 3800 m., Cordillera de Lallinca, Province of Tarapacá, Department of Tarapacá, Chile, March, 1926 (type, Herb. Gray: cotypes, Herb. Field Mus.; Herb. Mus. Stockholm; Herb. Univ. California, etc.).[6]

Coreopsis macbridei sp. nov.—Frutex glabratus, ramosus, caulibus subteretibus. Folia laxe disposita, opposita, petiolata petiolis tenuibus circ. 1–1.5 cm. longis, primaria petiolo adjecto etiam 4–4.5 cm. longa, pinnatim 5–7-secta, segmentis anguste linearibus, glaberrimis, apicaliter acribus, 1–2.5 cm. longis et 1–1.7 mm. latis. Capitula corymboideo-paniculata, numerosa, tenuissime pedunculata (vel pedicellata) pedunculis saepius 3–7.5 cm. longis glaberrimis vel apicem versus vix pubescentibus, radiata, pansa ad anthesin tantum circ. 2 cm. lata et 6–9 mm. alta. Involucri glabrati sicci subnigri bracteae exteriores circ. 8, lineari-oblongae, obtusae, tantum circ. 1.5–2 mm. longae; interiores oblongo-ovatae circ. 5–6 mm. longae. Flores ligulati circ. 8, fusco-flavi, ligula lineari-elliptici, apicaliter integri vel rarius denticulati, tantum circ. 8–10 mm. longi et 1.5–3 mm. lati. Paleae lineari-oblongae, circ. 5-striatae, tergo villosissimae ventre glabrae, cum achaenio deciduae. Disci florum stig-

[6] The label on the Field Museum sheet says, "Cord. Co. Columfusca, Apacheta, Prov. Tarapacá. . . . ."

mata incrassata et minutissime caudato-appendiculata. Achaenia lineari-oblanceolata, valde obcompressa, dorso sub palea glabra, ventre ad costam medianam villosa, marginibus longe perspicueque villoso-ciliata, apice biaristata aristis sursum villosis circ. 2 mm. longis.

Specimens examined: *J. Francis Macbride* 3504, neat compact half-shrub (or shrub) of southwestern rock outcrops, alt. about 7000 feet, Huanuco, Peru, Apr. 26, 1923 (type, Herb. Field Mus.: cotype, Herb. U.S. Nat.); *idem* 3152, ragged shrub, river-canyon slopes, alt. about 7000 feet, Ambo, Peru, Apr. 4, 1923 (Herb. Field Mus.; Herb. U.S. Nat.).

The specimens examined had been determined by Dr. S. F. BLAKE as a form of *Coreopsis townsendii* Blake, with more leaf lobes than on the type. A careful comparison with the type of that species in Field Museum, however, shows many striking differences. *C. macbridei* has a more scraggly habit; its leaves fewer, their petioles narrower and their divisions 5–7 rather than usually 3; the capitula more numerous (more than 30 on one sheet), their peduncles and involucres almost completely glabrous (not conspicuously tomentose), their external bracts about 1.5–2 mm. (not 4–4.5 mm.) long, their diameter at flowering about 2 cm., not 2.5–3 cm., the ligules deep yellow (not light yellow) and only about 8–10 mm. long and 1.5–3 mm. wide, not 15–18 mm. long and 5–7 mm. wide, etc.

Coreopsis imbricata sp. nov.—Frutex 6–12 dm. altus, caule ramisque glabris, striatis, ramulorum internodiis numerosis saepius tantum 2–10 mm. longis. Folia opposita, petiolata petiolis tenuibus basi vix connatis circ. 1 cm. longis, petiolo adjecto circ. 2–2.5 cm. longa, ternatim bipinnatisecta, segmentis linearibus, crassiusculis, glabris, eciliatis, acriter apiculatis, 2–8 mm. longis et circ. 0.3–0.6 mm. latis. Capitula ramulos terminantia (vix manifeste pedunculata), radiata, pansa ad anthesin 3.5–4.5 cm. lata et 1–1.2 cm. alta. Involucri villosi bracteae exteriores circ. 16, biseriales, late linearioblongae, apice obtusae, 6–7 mm. longae et 1.1–1.5 mm. latae; interiores ovatae, flavo-marginatae, obtusae, 1–1.1 cm. longae. Flores ligulati circ. 8, flavi, ligula oblongo-elliptici, apice integri vel subintegri, 1.8–2.4 cm. longi et 6–7 mm. lati. Paleae lineares, circ. 5-striatae, apice obtusae et denticulatae, ± 8 mm. longae et ± 0.5 mm. latae. Disci florum stigmata caudato-apiculata. Achaenia li-

neari-oblanceolata, plana, atra, dorso glabra, ventre ac marginibus ac apice sursum villosa, corpore ±5 mm. longa et ±1.4 mm. lata, biaristata aristis sursum hispidis ±2.7 mm. longis.

Specimens examined: *Mr. R. Pearce*, alt. 12000 ft., Cordillera Huanta (midway between Lima and Cuzco), Peru, February, 1867 (type in Herb. Kew).

Close to *Coreopsis pickeringii* Gray, from which it differs in its numerous, much shorter internodes, its lack of elongate peduncles, the caudate-tipped stigmas of its disk florets, its double outer involucre the bracts of which are larger (with a most noticeable *imbricate* appearance), etc.

Clavis specierum austro-americanorum Coreopsidis

a. Folia indivisa
  b. Folia oblanceolata, 5–7 mm. lata.....5. *C. oblanceolata*
  b. Folia angustiora
    c. Folia lineari-flagellaria tantum 0.5–1 mm. lata, totam longitudinem aequaliter angusta.....6. *C. longula*
    c. Folia augustissime spathulato-linearia, 1–2 mm. lata..... 7. *C. venusta*

a. Folia divisa
  b. Folia primaria minuta, tantum 7–9.5 mm. longa ramorum internodiis subaequalia.....8. *C. senaria*
  b. Folia primaria majora
    c. Capitula pansa ad anthesin circ. 1.1–2 cm. lata; foliorum laminis vel segmentis 1.5–4 mm. latis
      d. Partes novellae glaucescentia; involucri bracteis exterioribus linearibus quam interioribus dimidio brevioribus .....1. *C. glaucodes*
      d. Nullae partes glaucescentes
        e. Involucri bracteae exteriores minutae, longitudine tantum circ. tertiae interiorum
          f. Involucri bracteae exteriores ovatae; foliorum segmentis lateralibus cuneatis vel elliptico-obovatis vel spathulatis, 2–6 mm. latis.....2. *C. microlepis*
          f. Involucri bracteae exteriores lineari-oblongae; foliorum segmentis lateralibus anguste linearibus, 1–1.7 mm. latis.....3. *C. macbridei*

e. Involucri bracteae exteriores lineari-oblongae, quam interiores dimidio breviores.....4. *C. parviceps*

c. Capitula pansa ad anthesin 2.2–5 cm. lata

d. Folia densissime congregata, ramis fere abditis

e. Foliorum segmenta lineari-oblanceolata, apicaliter subobtusa; involucri bracteis exterioribus circ. 8, oblongis, apice rotundatis, circ. 5 mm. longis et 1.5 mm. latis, uniseriatim dispositis.....9. *C. foliosa*

e. Foliorum segmenta lineari-subulata, apicaliter acuta; involucri bracteis exterioribus circ. 11, ovatis, circ. 6 mm. longis et 3.3–4.8 mm. latis, biseriatim dispositis.....10. *C. polyactis*

d. Folia plerumque laxius (*C. trilobae* interdum dense) disposita, ramis plus minusve manifestis

e. Foliorum segmenta ultima lanceolata vel oblonga; involucri bracteis exterioribus 2–3 mm. longis et 1–1.6 mm. latis.....11. *C. notha*

e. Foliorum segmenta ultima angustiora

f. Foliorum triloborum segmenta ultima flagellaria, apicaliter acuta, 1–3.5 cm. longa et plerumque 0.3–0.6 mm. lata

g. Folia laxissime patentia vel etiam subreflexa.....12. *C. capillacea*

g. Folia dense adgregata, suberecta....13. *C. triloba*

f. Foliorum segmenta ultima diversa

g. Involucra glaberrima.....14. *C. spectabilis*

g. Involucra (saltem infra) hispida

h. Rami foliaque hinc illinc resinosa, suaveolentia.....15. *C. suaveolens*

h. Rami foliaque diversa (petiolis raro inferne resinosis)

i. Involucri bracteae exteriores biseriales, circ. 16.....17. *C. imbricata*

i. Involucri bracteae exteriores uniseriales, multo pauciores

j. Foliorum primariorum multa 2.5–4.5 cm. longa

k. Achaenia villoso-ciliata dorso sub palea glabra sed ad ventrem villosissima..... .....16. *C. pickeringii*

k. Achaenia villoso-ciliata sed faciebus glabra.....18. *C. townsendii*

j. Folia primaria 1–1.8 (–2.5) cm. longa..... .....19. *C. fasciculata*

Conspectus specierum austro-americanorum Coreopsidis

1. C. GLAUCODES Blake & Sherff *ex* Sherff, BOT. GAZ. **80**:369. 1925.—Peru.

2. C. MICROLEPIS Blake & Sherff *loc. cit.* 370.—Peru.

3. C. MACBRIDEI Sherff, *supra* p. 369.—Peru.

4. C. PARVICEPS Blake & Sherff *loc. cit.* 368.—Peru.

5. C. OBLANCEOLATA Blake, Contrib. U.S. Nat. Herb. **22**:642. 1925.—Peru.

6. C. LONGULA Blake, *loc. cit.*—Peru.

7. C. VENUSTA H.B.K. Nov. Gen. et Sp. **4**:229. 1820.—Ecuador.

8. C. SENARIA Blake & Sherff *loc. cit.* 367.—Peru.

9. C. FOLIOSA A. Gray, Proc. Amer. Acad. **5**:125. 1861.—Peru.

10. C. POLYACTIS Blake & Sherff *loc. cit.* 372.—Peru.

11. C. NOTHA Blake & Sherff *loc. cit.* 373.—Peru.

12. C. CAPILLACEA H.B.K. *loc. cit.* 230.—Eucador.

13. C. TRILOBA Blake *loc. cit.* 643.—Ecuador.

14. C. SPECTABILIS A. Gray, *loc. cit.*—Peru.

15. C. SUAVELOENS Sherff, *supra* p. 369.—Chile.

16. C. PICKERINGII A. Gray, *loc. cit.* 124; *C. boliviana* Blake, *loc. cit.* 644.—Peru and Bolivia.

17. C. IMBRICATA Sherff, *supra* p. 370.—Peru.

18. C. TOWNSENDII Blake, *loc. cit.* 643.—Peru.

19. C. FASCICULATA Wedd. Chlor. And. **1**:71. 1855.—Ecuador (where apparently rare) to Peru and Bolivia.

CHICAGO NORMAL COLLEGE

[*Accepted for publication March 28, 1930*]

BASICLADIA, A NEW GENUS OF CLADOPHORACEAE

WM. E. HOFFMANN AND JOSEPHINE E. TILDEN

(WITH TWENTY-TWO FIGURES)

Most people are familiar with the term "moss back" as applied to the common snapping turtle, or perhaps have noticed turtles coated with green "moss," in reality green algae. It is surprising to find that little attention or study has been given to the form which lives in this unusual habitat.

Probably the first reference in literature to this subject was a note by GADOW (6) in 1901, concerning snappers in captivity:

> Freshwater algae grow on the shell and in the mud which settles on it, and since this happens also in the wild state, they [the turtles] are rendered as inconspicuous as old rotten logs.

A few years later COLLINS (1, 2) described a new species of *Chaetomorpha*, *C. chelonum*, based on collections taken from the backs of turtles, *Chrysemys marginata* and *Aromochelys odorata*, in Michigan. Later COLLINS (3) saw a turtle with a distinct green growth on the shell, at Tewksbury, Massachusetts, and this material proved to be the same species, *C. chelonum*. DITMARS (4) states: "As the snapping turtle is persistently aquatic the shells of many specimens become coated with moss." EVERMANN and CLARK (5) studied the turtles of the Lake Maxinkuckee region, Indiana, and went into considerable detail in notes relating to the algal coating of certain kinds of turtles. Describing *Kinosternon odoratum* (Latreille), they state:

> Like the snapper, the musk turtle is frequently covered with algae on the back, the algae often being quite long and thick. The proportion of turtles covered with algae varies with the season and conditions; in early summer, before the scutes were shed, all or nearly all the turtles would probably be covered; with the shedding of the epidermal scutes the turtle comes forth clean of algae, and bright in color. . . . . During the late summer and early autumn of 1906, many small musk turtles were seen surrounded by a white halo which was conspicuous at a distance, very much resembling the general appearance of *Saprolegnia* on fishes. It was found upon examination that the white growth consisted of a dense growth of a stalked branched protozoan, *Opercularia*. Later it was found that larger musk turtles harbored considerable masses of

the protozoan on the plastron, this being frequently entirely covered, so that the turtles were practically botanical gardens above and zoological gardens below. Neither the alga nor the protozoan appears to do the turtles any injury. The algae above may assist the turtle in concealment; the protozoan below is self-supporting, feeding on minute organisms. The turtles in the muddy waters of Lost Lake are much more heavily overgrown than those of the clearer waters of Lake Maxinkuckee.

In writing of the western painted turtle, *Chrysemys marginata* Agassiz, EVERMANN and CLARK state:

As the epidermal scutes of these turtles grow old they occasionally become covered with various growths. An alga which appears to belong to the genus *Microspora* grows on the dorsal scutes, and less frequently a branched stalked *Opercularia* grows on the ventral scutes. Sometime during the year, usually in the late summer, the turtles shed these epidermal scutes, and can frequently be seen with some clean new scutes and old overgrown ones. . . . . In the autumn of 1906 one of these turtles was caught with the alga on it in fruit, the base of the alga being green, while the fruiting tips had a reddish cast.

SHUFELDT (10) notes:

I remember a specimen I had that was not more than an inch in length, from the back of which grew a long tassel of elegant green moss, fully twice the length of the turtle. This moss streamed out from behind it in a very attractive fashion, as it swam the length of the aquarium.

Also, TIFFANY (11) recorded the finding of COLLINS' *Chaetomorpha chelonum* in Iowa: "Collected from backs of turtles, *Chrysemys marginata belli*, ... taken from Miller's Bay and Lake West Okoboji, July and August, 1915 and 1923."

During the summer of 1923, while a study of the snapping turtle was being made, a specimen coated with an unusual abundance of green algae was found at St. Peter, Minnesota. It was supposed that the alga must be some common species, but to make sure a sample was collected and preserved in formalin. This specimen, when examined under the microscope, proved to be a plant with very distinctive characteristics, and easily attributable to COLLINS' *Chaetomorpha chelonum*, except for the fact that its dimensions were much larger. Its most peculiar and interesting character was not at once observable, however, and a more careful examination has indicated that this distinctive character, that of branching, justifies its receiving generic rank.

KÜTZING (7) founded the genus *Chaetomorpha* in 1845. SETCHELL

and GARDNER (9) made a very definite statement which seems to indicate that there has been no change of opinion concerning the validity of KÜTZING'S original description so far as it has to do with the question of branching.

> It [*Chaetomorpha*] seems to be generally recognized as a genus and to be retained in spite of the fact that it approaches *Rhizoclonium* on the one side and *Hormiscia* on the other. From *Rhizoclonium* species in typical form it is readily to be distinguished by the lack of branches of any kind, rhizoidal or otherwise.

No material of *Chaetomorpha chelonum* is available for examination, but COLLINS' (1) description proves beyond a doubt that it branches at the base at least, and that otherwise (except in size) it is in agreement with the Minnesota plant.

TIFFANY'S (11) notes on his collection of *C. chelonum* in Iowa are as follows:

> Zoospores, produced throughout the first and second week of July, 1925, are very small and quite numerous in the cell, escaping through an opening near the middle of the cell. The basal cells are very long, ending in tortuous holdfast appendages. The cells gradually become shorter and thicker and the cell wall relatively thinner from base to apex of the filament. Its unique habitat makes its identification almost certain even when "on the move."

A second collection of this same plant was made in Minnesota in July, 1926, from the shell of a turtle kept in a tank of running water in the Zoological Museum, University of Minnesota. One of the basal coenocytes was measured and drawn, being 32 mμ wide and 1840 mμ long. The Minnesota specimens, except in the matter of size, agree in every respect with those of COLLINS and TIFFANY, but in addition they show the presence of horizontal rhizome-like filaments and instances of true branching in the upper portions of the erect filaments.

To examine the material under the microscope, the closely woven "membrane" must be teased apart into separate portions or small clumps of filaments having somewhat the appearance, at the base at least, of clumps of bamboo. There is no difficulty in being able to find quantities of apparently unbroken basal segments, resembling those of a true *Chaetomorpha*, detached from the membrane but having a holdfast with rhizoidal processes. On the other hand, it is almost impossible to secure a single entire plant showing the

basal branching, that is, the branching of the basal coenocyte. We were successful in a very few cases in extracting a specimen showing true branching of the basal coenocyte (fig. 2). Usually the two branches were equally strong and were of practically the same diam-

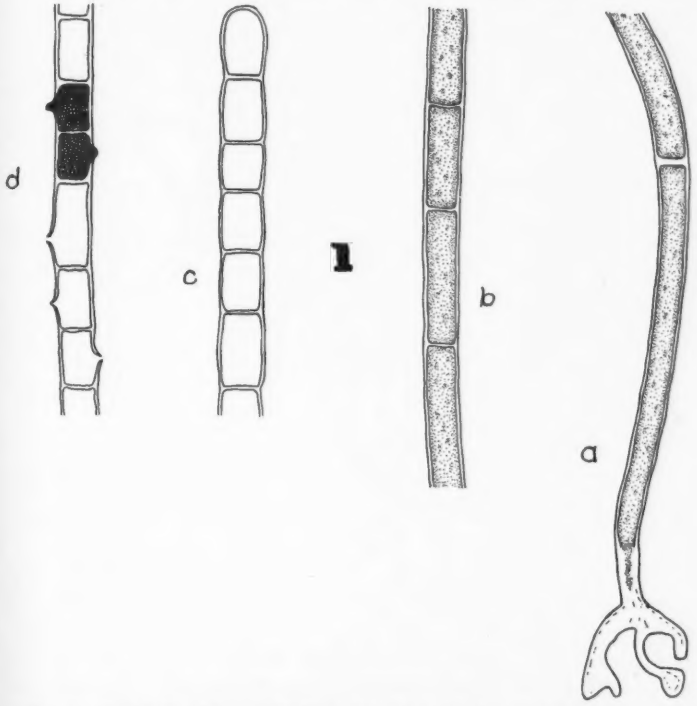
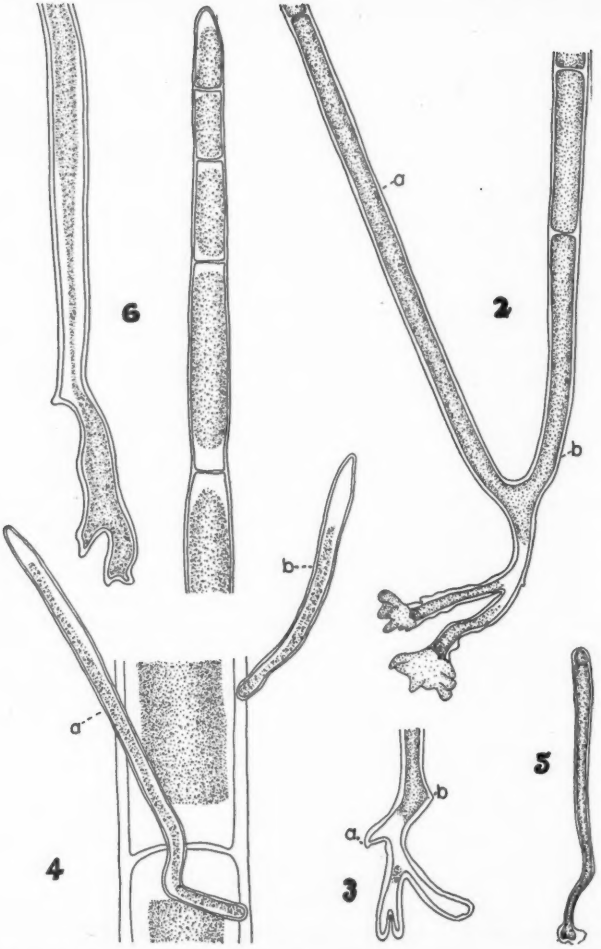


FIG. 1.—*Basicladia chelonum* (Collins) "showing the characteristically long basal cell with tortuous holdfast appendages, the gradual shortening and widening of cells from base to apex of filament, and zoospore formation." After TIFFANY.

eter and length. The basal segment of one branch (fig. 2*a*) was 1764 mμ in length. No good specimen of the horizontal or creeping filaments was found, but in numerous cases their presence was indicated by the broken end seen in the lower portion of basal coenocytes (figs. 3, 8).

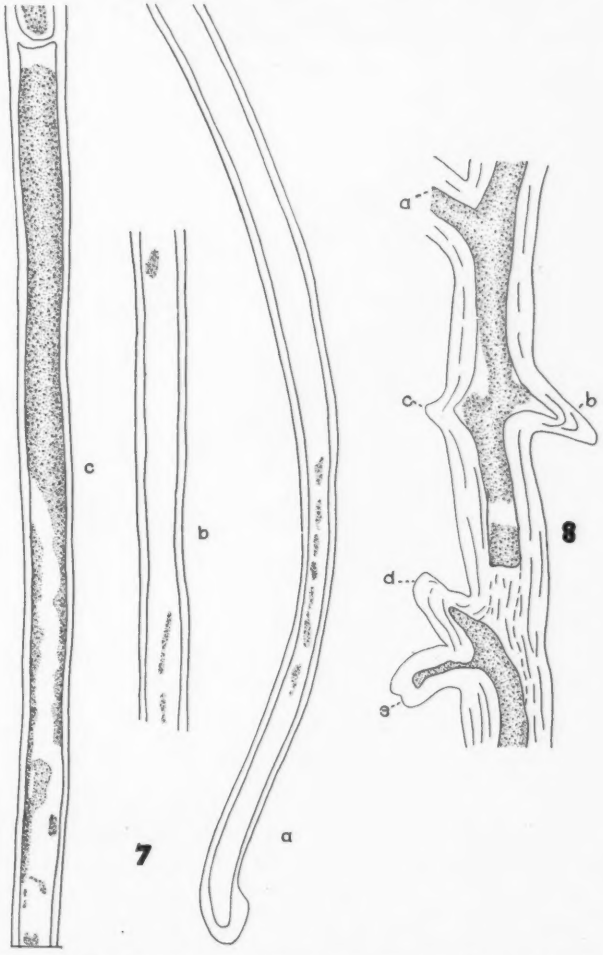
In the presence of creeping rhizome-like branches and branched



FIGS. 2–6.*—*B. crassa:* dichotomously branched basal coenocyte of upright filament, longer member (*a*) measures 75×1764 mμ; shorter (*b*), 98×377 mμ. Fig. 3, portion of holdfast showing free and coalesced rhizoidal processes and remains (?) of horizontal rhizome-like filaments (*a*, *b*). Fig. 4, two young plants attached to wall of old coenocyte (*a*, 21×262; *b*, 19×182 mμ). Fig. 5, young plant with apical coenocyte just formed. Fig. 6, young plant consisting of six coenocytes (basal segment 28×540, apical coenocyte 29×75.6 mμ); ×100.

* Figs. 2, 3, 5, 7, 9, 10, 13, 14, 20, 21 drawn with camera lucida by W. E. H. All other figures drawn ×100: fig. 4, M. G. FORBERG; fig. 6, K. B. WEBB; fig. 8, W. F. ADAMS; figs. 11, 17, O. VITEK; figs. 12, 15, 16, G. BOE; figs. 18, 19, H. V. WILDES; fig. 22, H. BERGLUND.

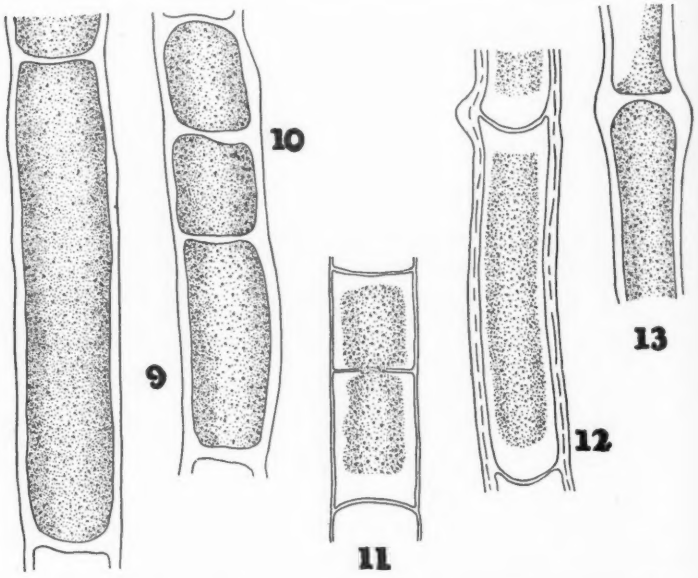
holdfasts the plant bears a close resemblance to such members of the Siphonales as *Derbesia* and *Caulerpa*. A search for branching in the upper portions of the plant was finally rewarded. A large



FIGS. 7, 8.—Fig. 7, one of longer basal coenocytes, more than 2 mm. in length; fig. 8, portion of old basal coenocyte showing points (*a–e*) where horizontal filaments have been broken off; ×100.

branch was seen but was lost before a permanent mount could be made. A second and smaller specimen (fig. 22) was preserved and careful measurements and drawings have been made of it.

A cytological study of the plant is in progress and for that reason no mention is made of the cellular contents in this paper.

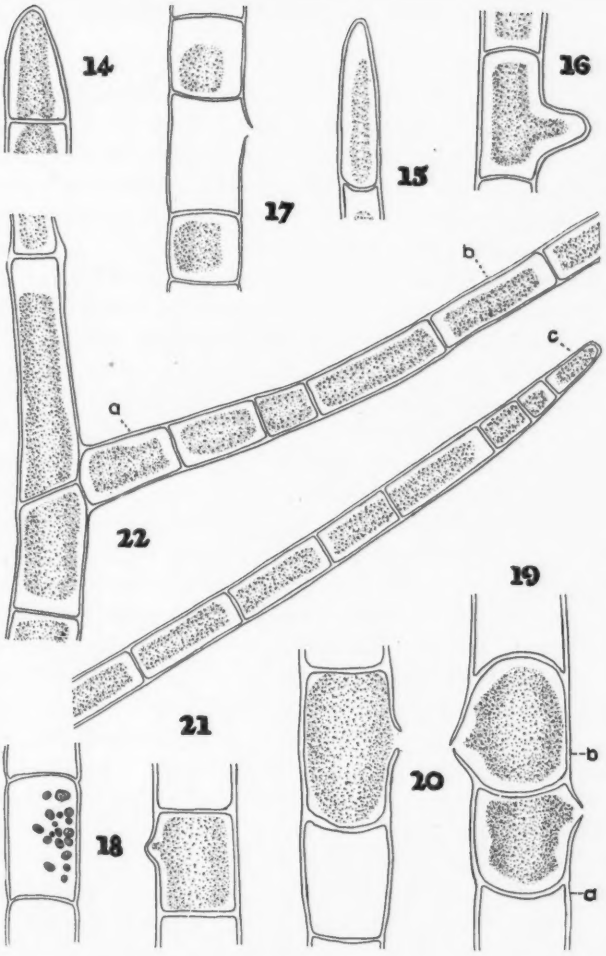


FIGS. 9–13.—Fig. 9, long coenocyte from lower portion of erect filament (85×387 mμ); fig. 10, two short coenocytes in median portion of erect filament; fig. 11, dividing coenocyte (75×184 mμ) with daughter coenocytes unequal in length; fig. 12, long coenocyte from lower portion of erect filament (71×290 mμ) showing wide lamellate wall thickened at node; fig. 13, coenocyte from lower portion of erect filament showing thickening of wall at node; ×100.

The following description is prepared and the genus named.

Basicladia Hoffmann and Tilden, gen. nov.

Fronds consisting of numerous multicellular, erect, somewhat rigid, sparingly branched, more or less cylindrical filaments arising from creeping, rhizome-like filaments which are fastened to the substratum (shell of turtle) by holdfasts having free or coalesced branches; basal coenocytes very long, rarely branched; coenocytes



FIGS. 14–22.—Fig. 14, apical coenocyte of erect filament. Fig. 15, apical coenocyte (42 mμ wide at base, 25 mμ at tip, 147 mμ long). Fig. 16, coenocyte in lower part of erect filament, with young branch (?). Fig. 17, empty sporangium, unchanged in shape, with pore (74×107 mμ). Fig. 18, sporangium (71×107) containing zoospores (gametes?) measuring 6–7×10–11 mμ. Fig. 19, sporangia (*a*, 88×92 mμ; *b*, 94×98 mμ) with contents unchanged but pores fully developed and open. Fig. 20, sporangium showing open pore. Fig. 21, sporangium with unopened pore. Fig. 22, mature branch produced from twenty-second coenocyte from base of erect filament (basal coenocyte of branch *a*, 56×101; *b*, 42×126; *c*, 28×59.5 mμ); ×100.

gradually becoming shorter and wider from base to apex as upper coenocytes are transformed into sporangia, but immature filaments tapering in upper portions with attenuate apical coenocyte; wall of segments thick, firm, usually distinctly lamellate, sometimes thickened at nodes, relatively thinner from base to apex of upright filaments; reproduction by zoospores (?) produced in upper coenocytes, escaping through a pore.

Type species, *Basicladia crassa* Hoffmann and Tilden.

Type in the Herbarium of the Department of Botany, University of Minnesota, collected from shell of a common snapping turtle, *Chelydra serpentina*, at St. Peter, Minnesota, August 17, 1923, by *William E. Hoffmann*.

Key to species

Upright filaments reaching a diameter of 50–120 mμ . . . . . 1. *B. crassa*
Upright filaments 35 μ or less in diameter . . . . . 2. *B. chelonum*

1. **Basicladia crassa** Hoffmann and Tilden, sp. nov.—Fronds bright or dark green; horizontal layer composed of branching interlacing filaments from which arise upright filaments; upright filaments 2 cm. or more in height, erect, straight, somewhat rigid especially in lower portions; basal coenocytes of upright filaments 50–120 mμ in diameter, up to 30 diameters or 1325–3175 mμ in length; following coenocytes 70–125×290–625 mμ, 4–8 diameters long; upper coenocytes 55–73×65–155 mμ, 1–2.5 diameters long; apical coenocytes 30–95×60–275mμ, 1.5–3 diameters long; sporangia (?) 64–127×87–179 mμ, 1–1.5 diameters long; basal coenocytes of upright filaments sometimes branched (dichotomously); upper coenocytes rarely giving off branches; upper branches long, straight, somewhat rigid, gradually tapering toward the apex, composed of many coenocytes; apical coenocyte of upright filaments and branches somewhat pointed.

Habitat: collected from shell of living snapping turtle, *Chelydra serpentina*, St. Peter, Minnesota, August 17, 1923, by *William E. Hoffmann*.

2. **Basicladia chelonum** (Collins) Hoffmann and Tilden, comb. nov.—*Chaetomorpha chelonum* Collins, Rhodora **9**:198–200. 1907; Green Algae of North America. Tufts College Studies **2**:326. 1909; Rhodora **11**:196, 197. 1909. Tiffany, Trans. Amer. Micr. Soc. **45**:78. pl. 12. figs. 138–141. 1926.

Basal layer a dense mass of very irregular, pluricellular, coralloid branches, forming a dense and continuous expansion on the substratum; erect filaments straight, 12–20 mμ diameter at base, increasing in size upward to 35 mμ in the upper part of the vegetative plant; lower coenocytes up to 1 mm. long, up to 50 diameters in length; following coenocytes 5–10 diameters long; upper coenocytes 2–3 diameters long; wall of coenocytes thick; sporangia in upper part of filament up to 50 mμ in diameter, 1–4 diameters long, from slightly moniliform to nearly globular; zoospores escaping by an opening near the middle of the sporangium, through a very short tube.

This species is known only from Michigan, Massachusetts, and Iowa. COLLINS' original material was found on the backs of turtles, *Chrysemys marginata* and *Aromochelys odorata*, Walnut Lake, Oakland County, Michigan, by Dr. T. L. HANKINSON. Later COLLINS made a personal collection from the shell of a turtle at Tewksbury, Massachusetts, in June, 1909. TIFFANY'S specimens were collected from backs of turtles, *Chrysemys marginata belli*, taken from Miller's Bay and Lake West Okoboji, near Milford, Iowa, July and August, 1915 and 1923.

COLLINS (1) recognized the fact that the plant branches, and refers to it in no uncertain terms:

> There are distinctly branching, pluricellular filaments, which unite to form a practically continuous layer on the substratum, the shell of the turtle. The basal developments of the individual plants are so closely united that the appearance is that of a continuous membrane, from which arise numerous erect, bright green, straight filaments, pretty uniformly increasing in size from the base to the apex. The cell wall is thick, in the lower cell about one quarter of the diameter; the cells in the vegetative filaments are nearly cylindrical, but the fertile cells are strongly swollen, sometimes nearly globular.

In all probability the green algae growing on the backs of turtles mentioned by the various writers quoted in this paper belong either to one or to the other of the two species described. It is hoped that other collectors may discover new material and give it further study.

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FERTILIZATION IN A LIVING OEDOGONIUM

EARLE AUGUSTUS SPESSARD

(WITH ELEVEN FIGURES)

Introduction

The genus *Oedogonium* is so large, so well investigated, and so widely used that new observations on the process of fertilization in any of its species must be of interest. No doubt many investigators have actually observed the act of fertilization in *Oedogonium;* not the cytological aspects as shown by fixed and sectioned material, but the passage of a living sperm into a living egg.

Such taxonomic works as those of HEERING (1) and HIRN (2) would not be expected to devote space to this matter. KLEBS (3) was more interested in the control of fertilization than in a description of the act. OLTMANNS (6) treats the matter in a comparative way from the morphological standpoint, as do also WEST and FRITSCH (8). KLEBAHN (4) has furnished a widely used illustration of fertilization in *O. boscii*. This figure, as reproduced in ENGLER and PRANTL, shows a sperm with the cilia pointed away from the egg, a condition which certainly never occurs at fertilization in the species investigated by the writer. Miss OHASHI (5) has observed fertilization in *O. nebraskense*.

This account deals only with the time element in the formation of sex organs, their period of maturing, the length of life of sperms, the time consumed in the act of fertilization, and the destiny of unsuccessful sperms. A short account is given also of the sperm.

Material

The plants of *Oedogonium* used were secured from a running stream in Clark County, Arkansas, November 3, 1928. No sex organs were visible when the plants were collected. The material was placed in culture and on November 10 separated into three masses. Two were placed in 20 cc. of river water in 25 cc. collecting vials, stoppered, and set in an east window. The third was used to distribute among five current cultures of various other algae. *Hydra*

viridis was placed in the two vials to keep under control the excessive reproduction of small crustaceans, which are harmful to many filamentous algae. *H. fusca* will do just as well for this purpose provided there is not an excess of sunlight and provided the container is spacious and uncorked. These two vials furnished enough material to observe all the stages in sex reproduction and zoospore formation within thirty days. Besides this material, they also furnished enough to begin new cultures. It is hoped that a means for growing the plant in pure culture may be found, so that its food requirements may be studied as well as the factors controlling reproduction. It is only through single zoospore isolation cultures that the life of a plant can be established.

The species under investigation has been identified by Professor L. H. TIFFANY as *Oedogonium kurzii* Zeller. I wish to thank him for his cooperation in the solution of this part of the problem.

TIME AND SEX ORGAN FORMATION

In vial *A* the first oogonia were seen November 15. These were almost ripe for fertilization and the antheridia were discharging in the afternoon of the following day. This set of sex organs was used for preliminary observations. Vial *B* furnished a rather complete record. The plants in it continued to vegetate until November 24, when the first oogonia were seen. The next day antheridia began to appear. By November 27 both were mature, and the next morning fertilization was observed to occur twice (table I). Fertilization had occurred in many oogonia in this vial previous to the observation of fertilization, as indicated by the number of sperms caught and observed to die within the oogonium. From the records of individual filaments it appears that fertilization may occur within forty-eight hours after the sex organs begin to differentiate.

PERIODICITY

There is a distinct periodicity observable in the production of sex organs. From the limited observations made on this point, there is some evidence that sex organs are formed at high peaks every fifteen days. A few are formed during the interval, but for the most part this time is consumed in a vegetative activity. The filaments finally become completely transformed into reproductive cells alternating with vegetative ones. The latter die and the filament fragments.

The antheridia of one filament develop a day later than the oogonia of the same filament. This insures against self-fertilization.

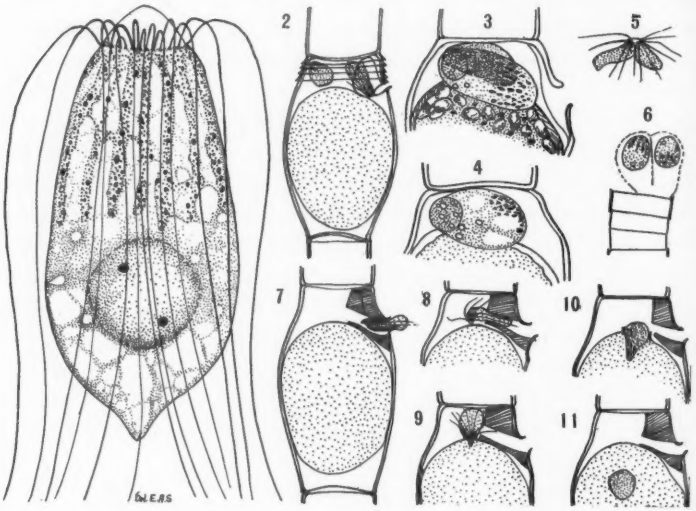
The most conspicuous periodicity is seen in the discharge of the sperms. They discharge in swarms between midnight and 4:00 A.M. There is a smaller display in the early hours of the afternoon. It is certain that they are discharged at any hour of the day, but to one who observes them continuously for a 24-hour stretch, this sudden increase in discharge of sperms is very evident. The oogonia, alternating with the antheridia, also show this periodicity.

Life of a sperm

While the life of a filament from the time it begins to produce sex organs until it is exhausted is but a few days, the life of a sperm can be counted in hours. Table I shows that no sperms of this species lived more than thirteen hours, and that most of them succumbed before that time. Many sperms were seen to enter the oogonium and were timed for the death point. Generally they ceased to move within two hours and then slowly enlarged to as much as twice their size and disintegrated about four hours later. This fact causes great loss of time to the investigator. The fact is that if he does not see fertilization take place at once, the sperm under observation will prove to be a dying one.

It is this point that differs from an interpretation of KLEBAHN'S figure. Invariably a sperm entering an oogonium in which the egg is already fertilized enters with the same avidity which sperms exhibit entering one not fertilized. Unlike the latter, they have not been observed to turn toward the egg, but on the contrary away from it, so that they come to rest or rotate with the ciliated end pointed into the farthest corner away from and above the egg, precisely as shown in KLEBAHN'S figure. In other words, a sperm in that position does not represent fertilization but a sperm that has entered an oogonium, the egg of which has already been fertilized. This criticism of KLEBAHN'S figure is not a reflection upon his observations, but calls attention to the unfortunate labeling of a preparation that is in the opinion of the writer slightly misleading. Figs. 2–4 show the sperm during its life in an oogonium in which the egg has already been fertilized. It is not rare to find two sperms in such an oogonium, and three were observed once.

The sperm is subject to the ordinary vicissitudes of its environment during its short life. Numbers 2 and 11 in table I illustrate what can and does frequently happen to swimming sperms. Destruction by foraging animals has been observed five times in all. Sperm number 9 illustrates the point that eviction of the sperm within a short time after discharge is necessary. A number of sperms were



FIGS. 1–11.—Fig. 1, sperm of *Oedogonium kurzii* showing large nucleus in colorless posterior region and chromatophore of anterior region; smaller vacuoles on either side of nucleus are contractile (dorsal view); ×1925. Fig. 2, oogonium containing fertilized egg and two sperms; ×192. Figs. 3, 4, upper regions of oogonia with sperms enlarged and disintegrating; small circles are contractile vacuoles, dark splotches coloring matter; ×352. Fig. 5, deformed sperm which reached mouth of oogonium but could not enter; ×192. Fig. 6, discharge of two sperms from antheridium; ×192. Figs 7–10, passage of sperm through oogonial conduit into fertilization chamber, establishing contact (fig. 8) and entering egg thirty seconds later (figs. 9, 10); ×192. Fig. 11, position of sperm two hours after entering egg; ×192.

observed in this and another species to be discharged not simultaneously. This may or may not be due to a faulty mechanism, but in every instance such sperms experienced difficulty in escaping from the membrane after discharge from the antheridium. Several of these were entirely unable to escape and died within the sheath after the normal manner.

One sperm (fig. 5) was deformed. It swam about for an hour and found an oogonium. The opening was not large enough to accommodate the deformity and the sperm died in due time at the pore.

Table I lists the history of the lives of fifteen sperms which were under constant observation during the periods indicated. A larger number of sperms were observed for various periods of time, but these are not listed because they are not complete records.

TABLE I

HISTORY OF FIFTEEN SPERMS OF OEDOGONIUM KURZII

INDIVIDUAL NUMBER	HOUR DISCHARGED	HOUR ENTERED	HOUR MOVEMENT CEASED	HOUR SPERM DISINTEGRATED
1	2:00 P.M.	3:00 P.M.	10:18 P.M.	12:01 A.M.
2	2:00 P.M.	Never	Devoured	11:30 P.M.
3	2:00 P.M	3:00 P.M.	11:20 P.M.	2:50 A.M.
4	10:00 A.M.	11:00 A.M.	1:05 P.M.	1:20 P.M.
5	2:00 P.M.	2:30 P.M.	5:10 P.M.	7:00 P.M.
6	8:15 A.M.	9:43 A.M.	10:30 A.M.	2:00 P.M.
7	6:00 P.M.	11:00 P.M.	11:50 P.M.	4:00 A.M.
8	3:00 P.M.	4:30 P.M.	6:30 P.M.	12:00 M.
9	3:00 P.M.	Never	5:15 P.M.	11:00 P.M.
10	2:35 P.M.	2:45 P.M.	8:45 P.M.	1:30 A.M.
11	10:00 A.M.	Never	Devoured	10:03 A.M.
12	9:35 P.M.	9:40 P.M.	12:45 A.M.	2:35 A.M.
13	3:40 P.M.	Never	5:20 P.M.	1:20 A.M.
14	2:00 A.M.	2:05 A.M.	Fertilization at 2:06 A.M.	
15	2:15 A.M.	2:45 A.M.	Fertilization at 2:49 A.M.	

Sperm number 1 swam out of the oogonium at 9:00 P.M. and number 5 at 5:00 P.M. These two sperms died on the slide. Number 9 failed to escape from the sheath after discharge from the antheridium.

TIME ELEMENT IN FERTILIZATION

The next question is naturally concerned with the act of fertilization itself, or rather that phase of it taken up by the passage of the sperm into the egg. This act was observed twice, in sperms 14 and 15 of table I. It is obvious from the table that considerable time may be spent in following false trails. This is due to the absence of knowledge regarding the most likely time for the event to occur, a knowledge of the periodicity involved, and, what is most important, a knowledge of the time it actually takes for a sperm to enter the egg. It is apparent from the table that if one is going to follow the method of following the trail of a sperm from the time it leaves the antheridium until it enters the egg, the chances are much in favor of

disappointment. It is interesting to observe the slow changes of a disintegrating sperm; but it is also conducive to erroneous interpretations if one is ignorant of the fact that the sperm is actually disintegrating and not entering the egg by a slow process. The nucleus becomes amoeboid during the last phases before death; the contractile vacuoles become very active and may number as high as sixteen. The sperm will increase to twice its original size and the nucleus will come to lie immediately in contact with what appears to be the egg membrane. In several cases fine protoplasmic lines apparently were seen to connect the nucleus and the egg. In another the starch grains of the egg were seen to move over the nucleus after the cytoplasm had become highly vacuolated, so that the nucleus appeared to be three-fourths of the way into the egg. During the time it takes to slip the camera lucida prism into place, perhaps thirty seconds, the protoplasm had burst and the nucleus had disappeared. This seemed to be genuinely a case of slow passage of the nucleus into the egg, leaving the balance of the sperm in the oogonium. But since the actual destiny of the nucleus was lost by thirty seconds of necessary diversion after a continuous observation of some nine hours, it had to be discarded as worthless data. Passage of the sperm into the egg is not a slow process.

On November 28, twenty-four days after the plants were brought from the field, and two days after the appearance of sex organs, two sperms were observed to enter separate eggs. The first consumed thirty seconds passing through the conduit into the fertilization chamber, and one second getting into position to enter the egg or making contact with it. The actual passage into the egg took thirty seconds. Judging from the length of the sperm, it traveled in this passage at the rate of 1.5 mm. per hour. The movement was a gliding one. The sperm did not change its shape during the passage although its lower mid-region was larger than the forward end. The most startling feature of this passage was the behavior of the egg. The cytoplasm spread apart in a slow splash so that it moved upward around the sperm with the fringes of the opening bent away from it. There was no sudden quickening of the movement of the sperm after the thickest portion had entered. As the tail end of the sperm disappeared into the egg substance this healed over, leaving no trace of the sperm's passage.

The second case differed from the first in no important particular. It consumed slightly more than four minutes getting through the conduit. In this passage the inner opening was smaller than the diameter of the sperm, which showed an undulating body movement similar to that of a *Paramoecium* passing through a hole. Its normal shape was resumed when inside the fertilization chamber. This sperm was seen to have a one-sided snout with which it made contact with the egg as soon as the head end had passed the inner portal of the conduit. There was no hesitation on the part of the sperm to assume a position vertical to the egg and establish its contact. Once this contact was made the sperm glided into the egg precisely as described for the other one. There was a distinct hyaline and granular fringe of cytoplasm observable in the egg, however, as it opened to receive the sperm, or rather as the sperm pushed the egg apart. This may be the receptive spot. To say that the egg opens for the sperm or that the sperm pushes open the egg is not accurate. There is no movement of the cilia which lie backward along the sperm that can account for the passage. More cases will have to be observed to explain the forces which cause the two organisms to function. This sperm could be seen within the egg after entry. It stopped in the upper part and remained there for two hours, at which time observation of it ceased.

It is clear from these observations of two sperms that the actual passage of the sperm is phenomenally rapid, taking about half a minute. The passage through the conduit may perhaps require five minutes, but this is probably unusual judging from observations made on numerous other sperms as they entered oogonia. The sperm generally manages to pass through the conduit in less than a minute. Actually then, fertilization normally occurs within a minute after the sperm reaches the oogonium. It sometimes reaches the oogonium within a minute after its discharge from the antheridium, so that it is possible that the entire process from sperm discharge to passage into the egg may transpire within two minutes. This means that the observer has little chance of seeing the process. If the period of maximum discharge of sperms is known, however, the observation is not difficult to make. It is certainly unprofitable to follow the sperm. If a sperm does not enter the egg at once after entering the oogonium, the egg of that organ may be assumed to have been fertilized previously.

LIVING SPERM

All the writers referred to in this paper seem to concur in the opinion that the sperm of *Oedogonium* is a miniature zoospore in appearance. The sperm of this species is larger than the zoospore of most species of the genus, so that its movements may easily be seen. A few points will be mentioned to show that this opinion of the nature of the sperm must be thoroughly examined.

The sperm of this species shows indications of dorsiventrality in several respects. First, at least one was observed to possess a definite apical point at the moment of contact with the egg. This point did not include the entire apical termination of the sperm but only about half of it. It was impossible to determine if the point was dorsal or ventral in position. In all specimens killed for observation the point was not observable, but killing the sperm alters its shape profoundly. The cilia which are normally extended backward along the body, unless in actual use, are slowly bent forward and become much shortened. This is the position shown in most figures; therefore any observations made on fixed material of sperms must be checked with observations of living sperms in this species at least. Second, the movement of the organism is more like that of a dorsiventral animal than one having another type of symmetry. The animal possesses cilia that are apparently equal in length although they seem not to be used in a wavelike rhythm. They are used more like oars, with possibly a few extending forward permanently as tactile organs. This is a degree of specialization not observed in zoospores, and can be explained on the basis of dorsiventrality.

Besides apparent dorsiventrality, the oscillating movement of the sperm is very unlike the rotating movement of zoospores of this and other species of *Oedogonium*. Also, the coloring matter of the sperm, admitting its evident reduction, is definitely distributed in the more anterior region of the body. There is no starch in the sperm, although this feature is undoubtedly connected with the reduced amount of chlorophyll. However, sperms and zoospores come from the same sort of cells within a few days of vegetative activity. The presence of oil in one and the absence of starch in the other indicate at least a chemical specialization or adaptation in the sperm not present in the zoospore. There are contractile vacuoles in the sperm

of this species. This organ has not yet been seen in the zoospores of the same species.

In the species under investigation, the sperm seems not to be a miniature zoospore but a highly differentiated cell differing from zoospores in important particulars.

Summary

1. Sex organs are mature approximately forty-eight hours after they begin to form.

2. The antheridia appear about a day after the oogonia, insuring cross fertilization between filaments.

3. The high peak in sex organ production occurs about every fifteen days.

4. The antheridia open and sperms are discharged most frequently between midnight and 4:00 A.M. Between noon and 4:00 P.M. there is another copious discharge.

5. The unsuccessful sperm lives between two and thirteen hours.

6. Fertilization may occur within two minutes after discharge of the sperms.

7. Passage of the sperm into the egg takes thirty seconds.

8. The sperm is not to be considered a miniature zoospore.

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CYTOLOGICAL FEATURES OF THE LIFE HISTORY OF GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 404

EDITH STEVENS

(WITH PLATES VII, VIII)

Introduction

The aim of the investigation here reported was to determine some of the general cytological features in the life history of *Gymnosporangium juniperi-virginianae*. The first intention was to work in detail the entire history, but the new questions which arose as the investigation progressed and the limited time did not permit such an extended study. The investigation deals with the origin of the teliospore, its ripening, germination, the reduction divisions, formation of the basidiospore, and finally includes a preliminary account of the aecia.

Material and methods

Cedar galls or "cedar apples" of *Juniperus virginiana* were collected in Indiana, Virginia, West Virginia, and Tennessee. Collections were made at weekly intervals during March, April, and May. Infected leaves were obtained from inoculations made by Dr. MOTTIER of Indiana State University, who collected twigs infested with *Gymnosporangium juniperi-virginianae* and placed them over *Pyrus coronaria* leaves in order to be certain of procuring infection. Inoculations of apple seedlings with *Gymnosporangium* were made in the University of Chicago greenhouse during the month of March, and in this manner stages in the development of pycnia and aecia were obtained. The next step was to inoculate *J. virginiana* with the aeciospores, then the complete life history of one species of *Gymnosporangium* would be assured. The species used was identified by careful checking of morphological differences of the teliosori, teliospores, the gall, and the host plants. By the process of elimination the species could be no other than *Gymnosporangium juniperi-virginianae*.

Most of the material for this investigation was killed in formalin-acetic-alcohol and stained with iron-haematoxylin. The galls were cut in tiny squares, each containing a single teliosorus, in order that the killing might occur as quickly as possible. The teliospore horns were detached from the gall, run through a close series of alcohols into glycerin, the glycerin washed out with absolute alcohol, and then taken through a close series of cedar oil (diluted with alcohol) into pure cedar oil. The material brought into paraffin by this method was easily cut at any desired thickness, but if the gelatinized horns were carried through the usual series of alcohols and xylols, the material became flinty and impossible to cut. If the horns were killed in chromo-acetic solution the gelatin disappeared, leaving only the teliospores, which were placed in onion skin bags and carried through the alcohols and xylols into paraffin in the usual manner, and were easily sectioned. Most of the sections were 5 or 7μ; if cut less than 5μ the sections were so fragmentary that it was hard to obtain satisfactory conclusions from them.

Germinating teliospores were stained and transferred to glycerin and Venetian turpentine, and the whole mounts which were made proved to be very satisfactory.

In order to obtain a large quantity of infected apple leaf material, seeds from Jonathan apples were planted February 13, 1928, and in the beginning of March inoculations of the seedlings were begun. Cedar apples placed in a very moist chamber were allowed to stand overnight. By that time the teliospores had sent out basidia and the basidiospores had formed, the latter easily discerned with the naked eye by the white appearance of the horns. The apple leaves were rubbed lightly to rid them of bloom, sprayed with distilled water, and the spores, suspended in water, dropped upon them. The plants were immediately placed in a glass cage and allowed to incubate for two days, when they were removed to the greenhouse atmosphere. The amber-colored pycnia appeared within eleven days and mature aecia within sixty days. If the leaves were not first rubbed and sprayed with water, however, the results were not so satisfactory, and often the leaves remained as healthy as before the treatment.

Investigation

Origin of teliospore

The cedar gall is made up of parenchymatous tissue, abundant mycelial threads of the fungus appearing everywhere, ramifying throughout the gall between the cells of the host. Immediately below the surface of the gall, where the teliospores are to be formed, there arise from the ends of the mycelial threads rows of parenchyma-like cells which are binucleate, like the mycelium from which they come (figs. 1–17). At the beginning of this process the ends of the mycelial threads orient themselves almost at right angles to the surface of the gall (figs. 3–8); the end cells divide vegetatively, the two nuclei in each cell dividing simultaneously and conjugately. Each nucleus elongates, and a split in the chromatin material suggests the presence of two chromosomes; while at the end of each nucleus may often be observed a dense area resembling a centrosome. Each nucleus becomes more and more elongated until it is practically pulled into two portions, the two parts being held together by a delicate strand which eventually disappears. Each of the four portions of chromatin round off into a nucleus (fig. 12), each cell containing two nuclei similar to those of the mother cell. This process has formed two cells, and the end cell then quickly forms two cells, making a row of three parenchyma-like cells (figs. 14, 15) as already mentioned. The upper cell gradually swells, becomes turgid, and loses its cytoplasm while the nuclei disintegrate (fig. 15). These upper turgid (buffer) cells help to rupture the corky layer covering them. The true basal cells, those immediately below the buffer cells, become active, and grow into and finally through the latter. There may be more than one outgrowth, often two (fig. 24), from a basal cell. While the basal cell is lengthening its nuclei divide conjugately, and one pair moves into each outgrowth or bud where they divide (fig. 23), one of the resulting pairs moving to the upper end of the cell. A wall then forms between the pairs of nuclei, cutting off a stalk cell from a terminal one (fig. 26). In this end cell the nuclei enlarge to normal size; then nuclear division occurs, giving rise to a four-nucleate teliospore mother cell (fig. 29). A wall is soon laid down, dividing the mother cell into two daughter cells which are the two cells of the teliospore, each containing two nuclei (fig. 30).

During the period of ripening the walls of the teliospore cells become much thickened, and the two nuclei in each of its cells unite, initiating a uninucleate condition (figs. 31, 32). The fusion nuclei in the teliospore show various phases (figs. 33–39), the final resting condition being shown in fig. 38.

Teliospore germination and formation of basidiospore

About the first of March the teliospore germinates readily; earlier than this the spores are not fully ripened and will not respond to conditions which are favorable for germination later in the season. The first indication of germination is the formation of papillae, globular protrusions of the cell contents through the germ pores; but since the single nucleus of a teliospore cell rarely divides within the cell, only one protrusion can develop into a basidium. As the protoplasm of the cell passes out the mass gradually elongates, forming the basidium, while the nucleus lengthens and passes to the middle of the filament. In several preparations the nucleus, as it passed through the germ pore, was observed to be much elongated and showed two distinct thickened threadlike masses (fig. 40). This process was assumed to be a precocious division of the nucleus, the assumption being borne out by several cases in which a nucleus was found in the germ tube and at the same time one still remained within the teliospore cell.

After the fusion nucleus has passed into the basidium, the chromatin appears on one side during synapsis, the nuclear phase initiating the reduction division. The nuclear membrane disappears and the chromatin begins to elongate into two dumb-bell-shaped masses, for the two portions of the fusion nucleus string out separately and the chromatin of each shows a faint split, indicating four chromosomes, the diploid number (figs. 46, 47). The short spindle is formed and gradually increases in length, while the chromatin moves toward the poles in the form of the two elongated masses, each consisting of four chromosomes. As the division draws to a close the nuclei are formed, each containing four chromosomes; a cross wall is immediately formed and the two new nuclei quickly divide. This time there is no splitting, two of the four chromosomes in each nucleus going to one pole and two to the other, so that four nuclei are formed, each with two chromosomes (the haploid number), indicating that reduction

has occurred. Transverse walls are laid down and each of the four cells of the basidium develops a tube, broad at the base and tapering to the top, the sterigma, which becomes inflated at the tip to form a basidiospore. A sterigma is formed by each of the four cells of the basidium, probably due to a weakened place in the cell wall; but why it is always located at the same point on the cell is not understood. The wall may be weakened by enzymatic action, and the pushing out would then result from the turgidity of the cell which is to produce the sterigma. Upon the formation of the sterigma the nucleus is either pulled or pushed into it. It may be that the nucleus is attached to a centrosome by a contractile strand which pulls it into the basidiospore, as was found to be the case in *Nidularia*. Often a precocious division of the basidiospore nucleus takes place, producing a spore containing two nuclei (fig. 56); for the spores immediately germinate. In some cases the four cells of the basidium put out longer germ tubes and do not form basidiospores. Basidiospores were seen which upon germination formed secondary spores.

Pycnia and aecia

About eleven days after inoculation, pycnia appeared as small amber spots on the upper surface of the leaf, developing between the epidermis and palisade layer. The mycelium gathers at a point just under the epidermis, and as it increases pressure is exerted on the tissue above, pushing it upward. The mycelium resolves itself into a sunken spherical structure whose periphery is surrounded by paraphyses, which later rupture the epidermis of the leaf.

As the aecia develop there is a proliferation of the cells of the leaf, and they sink into the host tissues as far as the palisade cells. It is known that the binucleate aeciospores are cut from a fusion cell, formed by the union of two uninucleate hyphae. The two cells which fuse have been thought to be similar, but it does seem that there might be a difference in them. It may be possible that a mycelium like that in the pycnia unites with that of the aecia, for the aecia rise in the neighborhood of the pycnia and do not form unless pycnia are first formed.

Discussion

This study of *Gymnosporangium juniperi-virginianae* agrees in the majority of the details, except in the reduction division, with other

findings in the same genus. In *G. clavariaeforme* BLACKMAN[1] does not agree with SAPPIN-TROUFFY[2] that in the reduction division the chromatin masses are chromosomes. In the present investigation the split in the chromatin material would indicate that SAPPIN-TROUFFY was correct in his assumption.

Often two small nuclei are found in a teliospore cell instead of a single large one. BLACKMAN states:

> These are, no doubt, the original paired nuclei of the teleutospore, which for some reason have delayed their fusion. Their fate is unknown, as two nuclei were never observed to pass into the germ-tube; probably they fuse later. There was no evidence that they represented the results of a precocious division.

The present work indicates that the late appearance of two paired nuclei within the teliospore cell may be the result of a precocious division, since frequently the fusion nucleus was observed to be in a process of division as it passed into the basidium (fig. 40).

The basidiospores are frequently binucleate, but this, like the two nuclei in the teliospore, is a precocious division in which the formation of a wall has been delayed.

Summary

1. A row of three parenchyma-like cells arise from the end of a mycelial thread, the upper one being the buffer cell and the one immediately below it the basal cell.

2. The cytoplasm of the buffer cell disintegrates, and buds of the basal cell grow up into and through the buffer cell. The bud cell divides and forms two, the stalk cell and the teliospore mother cell.

3. The nuclei of the teliospore mother cell divide, giving rise to a four-nucleate cell. A wall is laid down dividing the cell into two daughter cells each containing two nuclei.

4. The two nuclei in each of the teliospore cells unite, initiating a uninucleate condition.

5. The walls of the teliospores in the outer portion of the teliosorus are much thicker than those toward the center.

6. Upon ripening each cell of the teliospore sends out a basidium

[1] BLACKMAN, V. H., On the fertilization, alternation of generations and general cytology of the Uredineae. Ann. Botany **18**: 323–375. 1904.

[2] SAPPIN-TROUFFY, P., Recherches histologiques sur la famille des Uredinées. Le Botaniste. 5e serie. 59. 1896.

where reduction takes place, four cells being formed as a result of the process. The haploid number of chromosomes is two, and the diploid four.

7. Each of the four cells of the basidium forms a sterigma, which rounds off to form a basidiospore, the nucleus of each of the cells moving up through the sterigma into the spore.

8. Basidiospores often contain two nuclei as a result of a precocious division and the delay of the formation of a wall.

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EXPLANATION OF PLATES VII, VIII

FIGS. 1, 2.—End of mycelial thread in process of division.

FIGS. 3.—Group of parenchyma-like cells.

FIGS. 4–9.—End of mycelium in process of division.

FIGS. 9–12.—First cell near completion of division.

FIG. 13.—Cell in process of division, forming two cells (basal and buffer).

FIG. 14.—Three cells in row; top is buffer cell, one just beneath is basal cell.

FIG. 15.—Nuclei and cytoplasm of buffer cell disintegrating.

FIG. 16.—Buffer cell empty.

FIG. 17.—Basal cell with four nuclei; slight bulge on basal cell shows position of outgrowth arising from it.

FIGS. 18–20.—Basal cell with bud cell cut from it and growing into buffer cell.

FIG. 21.—Cell which originated from basal cell, exerting pressure inside walls of buffer cell.

FIG. 22.—Buffer cell wall broken by bud cell (with four nuclei); cell will form stalk and teliospore mother cell.

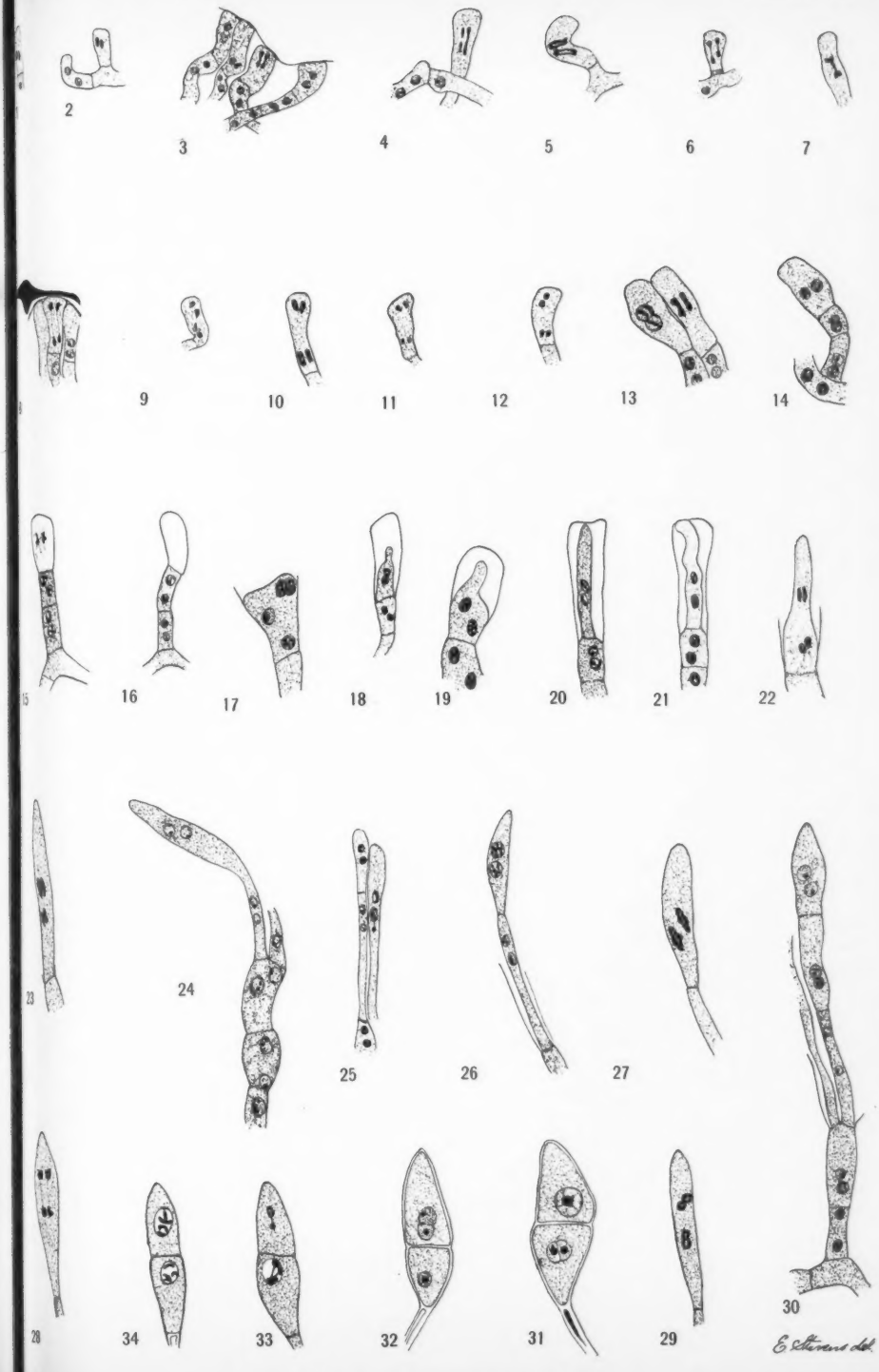
FIG. 23.—Nuclei of bud cell in process of division.

FIG. 24.—Four-nucleate bud cell which will form stalk and teliospore mother cell.

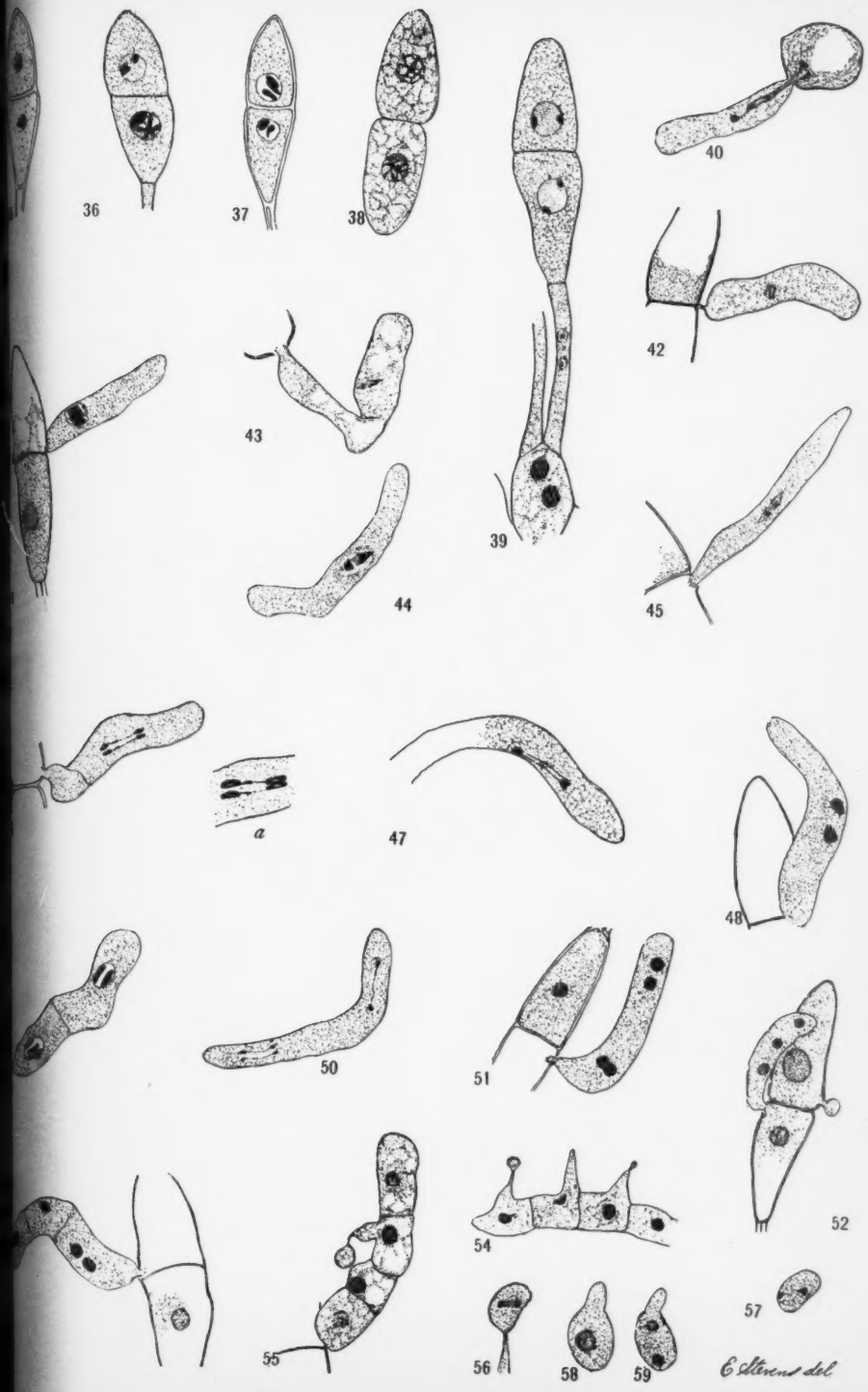
FIGS. 25, 26.—Stalk cell cut off and teliospore mother cell formed.

FIGS. 27, 28.—Binucleate teliospore mother cell dividing to form two cells of teliospore.

FIG. 29.—Teliospore mother cell with nuclear division completed.



STEVENS on GYMNOSPORANGIUM



STEVENS on GYMNOSPORANGIUM

FIG. 30.—Teliospore cells formed, each containing two nuclei.

FIGS. 31–33.—Nuclear fusion in cells of teliospore.

FIGS. 33–38.—Nuclear fusion completed, chromosomes still evident.

FIG. 38.—Teliospore with resting nuclei.

FIG. 39.—Basal cell showing two outgrowths, one having formed stalk cell and teliospore.

FIG. 40.—Germinating teliospore showing precocious nuclear division.

FIGS. 41–43.—Nuclear phases in basidium.

FIGS. 43–46.—First nuclear division in basidium, showing four chromosomes moving to each pole.

FIGS. 46–48.—First division of nucleus in basidium; fig. 46*a*, detail of division showing split denoting diploid number of chromosomes.

FIG. 48.—First nuclear division in basidium completed; wall not formed.

FIG. 49.—First wall formed in basidium.

FIG. 50.—Second nuclear division in basidium, where reduction from four to two chromosomes takes place.

FIG. 51.—Basidium with four nuclei; walls not yet formed.

FIG. 52.—Teliospore showing basidium containing three nuclei; one division must have taken place within teliospore cell and one nucleus has not moved into basidium.

FIG. 53.—Basidium with three cells; one wall late in forming.

FIG. 54.—Basidium with sterigmata, two showing basidiospore in process of formation.

FIG. 55.—Basidium with four cells.

FIGS. 56, 57.—Basidiospores showing precocious division of nuclei.

FIG. 58.—Uninucleate basidiospore in process of germination.

FIG. 59.—Binucleate basidiospore in process of germination.

CYTOLOGICAL STUDIES IN THE BETULACEAE

III. PARTHENOGENESIS AND POLYEMBRYONY IN ALNUS RUGOSA

ROBERT H. WOODWORTH

(WITH PLATE IX AND TWO FIGURES)

Introduction

While making collections of staminate catkins of *Alnus rugosa* (Du Roi) Spreng. for the study of microsporogenesis, certain observations seemed significant. The plant was noted to be highly polymorphic. Extensive tracts were found to bear very few of the pollen-bearing aments. Investigation showed the microsporogenesis to be typical of heterozygous plants whose parents do not have close affinities (**6**). The reduction division in all phases is entirely irregular, resulting in wholesale malformation of the pollen, only 2 or 3 per cent of which appears to be morphologically perfect. Practically every plant in acres of ground cover bore the fertile catkins in great abundance. That the seeds are viable is shown by the great number of seedlings which grow about the mature plants. It was deemed of interest to learn how such great numbers of seeds are formed when the staminate catkins are so scarce, and productive of practically no viable pollen grains.

Material and methods

Pistillate catkins were collected weekly from the time of pollination in early spring until mid-August. Carnoy's fluid was used for killing and fixing. The aments were carefully picked apart and the tiny ovaries placed on small squares of cardboard, about 100 on a square, according to JEFFREY'S mass method (**3**). The stain used was Haidenhain's iron haematoxylin. Drawings were outlined with a camera lucida and photomicrographs made with a Bausch and Lomb model K photomicrographic camera and a Zeiss microscope equipped with apochromatic lenses, compensated oculars, and a NA 1.40 Abbe condenser.

Embryo sac formation

Although the pollen is shed in early spring the embryo sac mother cell does not appear until some 3 months later. SWINGLE (5) writes of the Betulaceae:

> In most species the ovules are immature at the time of pollination and the pollen grains germinate and penetrate the styles where they lie dormant for several weeks, until the ovules are ready for fertilization.

The writer has examined several thousand pistils at various stages of development but has never detected any signs of pollen tubes.

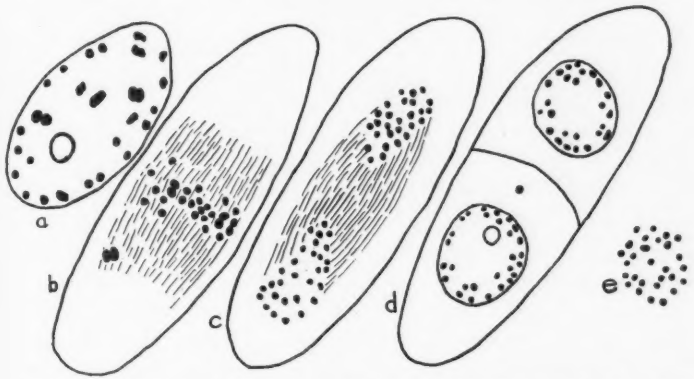


FIG. 1.—*a*, Diakinesis of embryo sac mother cell; *b*, metaphase of first division; *c*, anaphase of first division; *d*, interkinesis; *e*, metaphase plate of sporophytic cell showing twenty-eight chromosomes.

Since there is practically no perfect pollen formed, the absence of pollen tubes is to be expected unless pollen from the closely related *Alnus incana* could function. In the ovaries of *A. incana* pollen tube development is readily detected.

Embryo sac formation is initiated about mid-July. Text fig. 1*a* shows the nucleus of a typical embryo sac mother cell at diakinesis. Chromosome pairs characteristic of this stage are very scarce. This condition is identical with that in microsporogenesis (6), and indicates a heterozygous origin. The metaphase of the first division is shown in text fig. 1*b*. Most of the chromosomes are single. Apparently they split in halves at this division and reduction fails completely. Text fig. 1*c* shows the anaphase of the first division with

nearly the full chromosome complement at each pole; *d* is the interkinesis and again shows that reduction does not take place; *e* is the metaphase plate of a sporophytic ovulary cell showing the chromosome number to be twenty-eight.

The archesporium is of the massive type, not being limited to the production of but one embryo sac mother cell (text fig. 2). A very common condition in young ovules is shown in *b;* one embryo sac is mature and another is forming just above it. Occasionally three and four embryo sacs are formed in the same ovule. Text fig. 2*a* shows

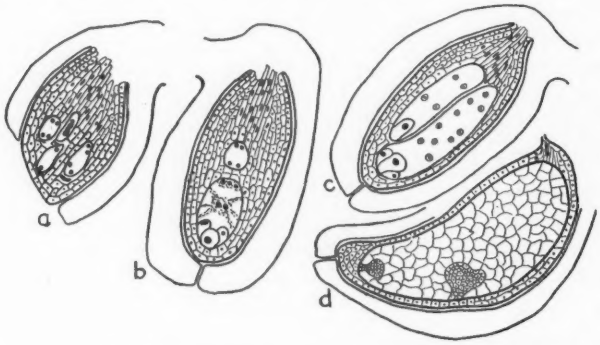


FIG. 2.—*a*, Ovule with four embryo sacs; *b*, *c*, ovule with two embryo sacs; *d*, ovule with embryo from diploid egg and embryo from nucellar budding.

one embryo sac mother cell in the spireme state and three embryo sacs in later stages of development. Free nuclear division of the endosperm initials in two embryo sacs previous to the division of the egg cell is seen in *c*. The several embryo sacs may all produce viable embryos, as will be seen later.

Although no pollen tubes have been seen in thousands of pistils, such evidence is of course inconclusive. Twenty-four clusters of the pistillate aments were bagged about a week before pollination time. According to the suggestion of Professor EAST, old photographic film was freed of the emulsion, rolled into tubes, and the edges stuck with 6 per cent celloidin. These transparent tubes were then slipped over the clusters of fertile catkins and the ends plugged with cotton. About 6 weeks later the tubes were removed to allow the catkins to enlarge normally without being cramped. Microscopic examination

and germination experiments have proved the seeds from these bagged catkins to be different in no particular from the normally formed seed.

Parthenogenesis, apogamy, polyembryony

There are two or rarely three ovules in the young ovary of *Alnus* seeds. Ordinarily one ovule degenerates, the other forming the embryo which completely fills the seed (fig. 1). An embryo may form and mature in each ovule (fig. 3). The normal embryo has its hypocotyl pointing toward the micropyle and stigmas, since it has arisen from the diploid egg at the micropylar end of the ovule (fig. 1). This typifies more than half of the seeds. Occasionally a seed is seen to have its embryo pointing in the opposite direction, toward the chalaza (fig. 2). This suggests the formation of the embryo from the antipodal cells of the embryo sac (apogamy). As yet the earlier stages of such embryo formation have not been found. It may be a case of nucellar budding such as is referred to later.

Polyembryony is of frequent occurrence. One of the embryos is usually parthenogenetic, being developed from the diploid egg, as the smaller embryo in text fig. 2*d*. All of the stages in parthenogenetic embryo building are demonstrable. At times an apogamic embryo forms from one of the synergids beside the parthenogenetic embryo (fig. 5). The writer's preparations include one seed with three well developed embryos which appear to have arisen from the egg and the two synergids.

Nucellar budding (vegetative reproduction) accounts for the formation of many of the extra embryos. Fig. 4 shows the condition as illustrated in text fig. 2*d* at a later stage of development. Fig. 15 shows two embryos developing from opposite sides of the embryo sac wall. A very young embryo is seen forming in the nucellus wall in fig. 19.

Although reported cases of embryo formation from endosperm material are regarded with doubt (**4**), it seems that such happens in *Alnus rugosa*. In fig. 6 a small dicotyledonous embryo appears at the micropylar end of the sac, while another embryo is apparently developing in the endosperm of the same sac. There is no connection with nucellar material on either side or above or below, as shown

by serial sections. There is a short structure on the upper end resembling a suspensor, which grades into the endosperm. Since this embryo is clearly surrounded by several layers of endosperm cells on all sides, it must have its origin in that material. Figs. 13 and 17 show embryos which proved to be completely surrounded by endosperm material.

Many of the photographs show seeds with interesting conditions of polyembryony, the origin of which is not always clear. Fig. 7 has an embryo sac with two embryos, the lower one bearing five or seven cotyledonary buds. It may be the result of fusion of several embryos. Fig. 8 shows three well formed embryos in the same embryo sac. In fig. 9 are three embryos in the embryo sac on the right, while in the other ovule is an embryo with four cotyledonary buds. Fig. 10 shows two embryo sacs in the same ovule, each with an embryo. The lower embryo has its hypocotyl at the chalazal end, and may have arisen either from the antipodals or as a nucellar bud. Three embryo sacs in the same ovule, each bearing an embryo, are seen in fig. 11. A peculiar condition appears in fig. 12. There is a single embryo in the upper embryo sac and four linear embryos in the lower sac. Fig. 13 shows five embryos in the same sac. Serial sections show them all to be completely surrounded by endosperm. There are no other embryos in this seed. Two nucellar embryos have arisen opposite each other (fig. 15), the one on the left sending two linear cotyledons around one side of the other embryo. One embryo appears in each of two embryo sacs in fig. 16. The larger embryo has sent a young cotyledon over into the other sac. There are two embryo sacs in the same ovule in fig. 17. The three embryos in the upper sac are all completely surrounded by endosperm (serial sections). Fig. 18 shows two embryo sacs with two embryos in each. The microscope shows the two embryos in the upper sac to be distinct. Three embryos have formed from the chalazal end of the embryo sac in fig. 19. Possibly each has come from an antipodal cell, or they may be from the nucellus. A nucellar embryo is just forming in the upper part of the ovule. Fig. 20 shows two embryo sacs with one embryo in the upper and two embryos in the lower sac. There are three embryos in the same embryo sac in fig. 21.

Germination tests

Mature seeds examined under the dissecting microscope showed polyembryony. Fifty seeds were sown on moist soil in the laboratory, and about half of them germinated. Of these, three showed two embryos arising from each seed. In one case the rapid elongation of one of the hypocotyls carried the seed into the air. The smaller hypocotyl stopped elongating when it lost contact with the moisture, and this embryo died before the seed dropped back to the ground. The other embryo is developing well. The two other cases of two embryos germinating from one seed are both living and developing normally. There has been but one cotyledon on one of the embryos from the start but it is in a healthy condition.

Mature seeds from the catkins which were bagged, thus preventing any pollination which might take place, were germinated. These are now growing well and differ in no way from those seeds which were formed naturally. Two of these seeds have produced two embryos each, which are developing normally.

Discussion

Since further investigation on this subject is to follow, it seems unnecessary to discuss at length previous work on parthenogenesis, apogamy, and polyembryony. The reports of Coulter and Chamberlain (1) and Sharp (4) treat these subjects well and give reference to most of the important original literature.

There are many well known examples of the phenomena here discussed, except embryo formation from endosperm material. Although this appears to have been demonstrated, it is hoped to detect the early stages of such embryo formation.

Polymorphism, irregularities of meiosis in both microsporogenesis and macrosporogenesis, parthenogenesis, apogamy, nucellar budding, and polyembryony all suggest a hybrid origin for *Alnus rugosa*. Ernst (2) applies this theory widely throughout the plant kingdom. Much cytological and genetical research lends strong support to his theory.

Summary

1. *Alnus rugosa* is polymorphic.
2. Due to irregularities of microsporogenesis there is practically

no perfect pollen formed. No pollen tubes have been seen in any of thousands of ovaries examined.

3. The plant sets an abundance of viable seeds. Bagged seeds form embryos just as natural seeds do.

4. There is no reduction in chromosome number during macrosporogenesis.

5. From one to four embryo sacs may form in one ovule. Embryos arise from the diploid egg (parthenogenesis) and by nucellar budding. They are also suspected of arising from the synergids, the antipodals, and the endosperm, although the initial stages have not yet been observed. From one to five embryos may mature in one embryo sac. Several embryos may mature in each of two embryo sacs in the same ovule.

6. Germination tests of naturally formed and bagged seeds proved equally successful.

7. Two embryos from the same seed can both develop to normal seedlings.

8. Polymorphism, irregular meioses, parthenogenesis, apogamy, nucellar budding, and polyembryony point to a hybrid origin.

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WOODWORTH on BETULACEAE

EXPLANATION OF PLATE IX

FIG. 1.—Normal embryo; hypocotyl at micropylar end of embryo sac.

FIG. 2.—Embryo with hypocotyl at chalazal end, possibly from antipodals.

FIG. 3.—Embryo in each ovule of ovary.

FIG. 4.—Two embryos in one embryo sac; one from diploid egg, other from nucellus.

FIG. 5.—Two parallel embryos in same embryo sac, probably from egg and one synergid.

FIG. 6.—Two embryos in one embryo sac; one from egg, other from endosperm.

FIG. 7.—Peculiar embryo complex; lower embryo with five or seven cotyledonary buds.

FIG. 8.—Three embryos maturing in same embryo sac.

FIG. 9.—Three embryos in same embryo sac at right, one tetracotyledonary embryo at left.

FIG. 10.—Embryo in each of two embryo sacs; larger may be from antipodals.

FIG. 11.—Three embryo sacs with embryo in each.

FIG. 12.—Two embryo sacs, upper with one embryo, lower with four embryos.

FIG. 13.—Five embryos in same embryo sac all apparently from endosperm.

FIG. 14.—Two embryos in same embryo sac; one from egg, other from nucellus.

FIG. 15.—Two opposed embryos from nucellar wall.

FIG. 16.—Two embryo sacs with embryo in each; cotyledon of one embryo extending into other.

FIG. 17.—Two embryo sacs, upper with three small embryos from endosperm.

FIG. 18.—Two embryo sacs with two embryos in each (upper two not connected).

FIG. 19.—One embryo sac with three embryos from antipodal region and one young embryo just forming in nucellus.

FIG. 20.—Two embryo sacs with one embryo in upper and two in lower sac.

FIG. 21.—One embryo sac with three embryos maturing.

BORON AS AN ESSENTIAL ELEMENT FOR HEALTHY GROWTH OF CITRUS[1]

A. R. C. HAAS

Although small amounts of boron are injurious to citrus species,[2] the presence of still smaller amounts may be harmless and even essential for their healthy growth. While boron has been shown by many investigators to be an essential constituent of a rather large and increasing number of plants, it has not previously been shown to be so for citrus.

For the past several years the writer has been employing boron as one of the elements of which traces have been added to the culture solution for the successful growth of citrus plants in water and sand cultures. The culture solution was made up from the following salts: sodium chloride, magnesium sulphate, potassium nitrate, calcium nitrate, potassium acid phosphate, and ferric tartrate. The composition of the culture solution expressed as parts per million was as follows:

Na	K	Ca	Mg	Fe	NO_3	Cl	SO_4	PO_4	Total
7	185	159	54	1	718	10	216	105	1455

The concentration of boron used in the culture solution was 0.2 parts per million. In addition to the boron, a similar concentration of aluminum, iodine, titanium, bromine, strontium, lithium, manganese, and ammonium was used. When traces of all of these elements were present in the culture solution an excellent growth resulted, whereas when they were omitted the growth was poor. In general the symptoms of decline may be described as follows. The leaves curled downward along the midrib, their color being a brownish or yellowish green, often with a yellowing along the midrib; the midrib or veins in many cases were conspicuous, corky, and split; and there was a progressive loss of affected leaves in a basipetal di-

[1] Paper no. 207, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station.

[2] KELLEY, W. P., and BROWN, S. M., Boron in the soils and irrigation waters of Southern California and its relation to citrus and walnut culture. Hilgardia **3**:445–458. 1928.

HAAS, A. R. C., Toxic effect of boron on fruit trees. BOT. GAZ. **89**:200–204. 1930.

rection. In severe cases there was a tendency toward "multiple bud" formation, due to new twigs dying when barely visible. The bark of the internodes of the basal part of the branch may split, when an amber-colored gum oozes out, the crack eventually widening so that the woody tissue is exposed. In these severe cases the apical portion of the branch dies back. The gumming differs from that characteristic of "exanthema" or "die-back," in which the gum pockets are at the leaf nodes. There is a marked reduction or even absence of flower production. The roots become dark brown, fail to elongate, and in advanced cases the rootlets decay. The addition of traces of these elements to the culture solution changes the state of the trees from one of decline to one of vigorous growth. In a few weeks it is impossible to find evidence of the former deficiency symptoms.

It is relatively much simpler to show that a small amount of boron is injurious to citrus than to show that the presence of a mere trace is essential to the good health of the tree. The problem, therefore, was to determine which elements added in traces to the culture solution were responsible for the improved growth.

The water used for the culture solution was distilled from a tin-lined copper still and stored in a copper tank lined with an electrolytic covering of tin. It is possible, therefore, that the water may have contained extremely small amounts of copper and tin. The sand cultures were grown in asphalted, galvanized iron containers, so that the roots had access to zinc. Copper, tin, and zinc were therefore not considered among the traces of elements added to the culture solution, although their possible importance is not being overlooked in further studies upon citrus nutrition.

In every case one grapefruit, one lemon, and one Valencia or Navel orange tree was included in each series of cultures. The galvanized iron containers were approximately 20 inches in diameter, 24 inches deep, and contained approximately 400 pounds of pure silica sand.

The first series received the culture solution without the traces of elements added. The tops of these trees in the course of about two years showed typical symptoms of decline. In the second series, where the culture solution contained traces of all nine elements,

growth was excellent. In other series of cultures all but one of the elements were added to the culture solution, a different one being omitted in each series. In each of these series the growth was excellent except (in cultures) where boron was omitted. The plants in these cultures to which no boron was added showed symptoms identical with those exhibited by plants in cultures receiving the culture solution alone. It is evident, therefore, that citrus plants do not grow satisfactorily without boron, and that traces of the other eight elements added to the culture solution have no visible effect.

Recently boron was added to a series of cultures which for the past two years have received none of the nine elements. Although the plants showed the symptoms ascribed to boron deficiency, within a week after traces of boron were added growth became active. It is known that citrus trees, which are in a declining state as a result of malnutrition, respond very slowly, if at all, to corrective treatments. This is due to the fact that such trees have lost most of their leaves, and the few remaining abnormal ones are unable to furnish the root system with sufficient food for proper growth.

It is of interest to consider sand cultures of citrus trees in 12-gallon earthenware containers which received the culture solution without the addition of the traces of elements previously mentioned. Under these conditions growth was excellent, indicating that the trees may obtain an adequate supply of boron from the vessel for the maintenance of good growth. Water cultures of leafy lemon twig cuttings have been grown successfully in Swedish enameled shallow mixing bowls without the addition of any of the elements in addition to the culture solution. On the other hand, in sand cultures in galvanized iron containers such a solution gave poor results. A booklet published by the American Potash and Chemical Corporation at Trona, California, 1928, states:

> Potters, vitreous enamelers, and agateware makers use borax extensively in fluxing the enamel and in glazing the pottery; 27 per cent by volume of the mixture forming the white coating on bathtubs and plumbing fixtures is borax.

It appears, therefore, that the enameled mixing bowls used and certain types of culture vessels may supply boron in amounts adequate for the healthy growth of citrus.

In water cultures the root decline usually precedes foliage decline. In sand cultures the symptoms of boron deficiency are quite obvious at an early stage from the appearance of the foliage, so that the trouble may be diagnosed in time to save the plants, as was the writer's experience with several hundred trees. Foliage symptoms have been observed in citrus orchards that were very similar to those artificially produced in boron-deficient sand cultures. It is quite possible, therefore, that a boron deficiency exists in some orchards. This possibility is being investigated.

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BRIEFER ARTICLES

CELLOIDIN TRANSFER METHOD FOR THIN ROCK SECTIONS

(WITH ONE FIGURE)

It is usually desirable to transfer sections of rock ground thin for microscopical observation from the glass slides on which they are ground and polished to other slides free from abrasions or other undesirable effects of grinding. In attempting a transfer the thin rock section is frequently broken. The following simple method, by means of which transfers may be made with a minimum of loss, is the utilization of a cellulose film transfer as worked out by LANG and ASHBY[1] in another connection.

1. Prepare in the usual way the rock specimen to be ground. In petrifactions, sections of rock 1–2 mm. thick may be cut by means of a rapidly rotating thin metal disk, the edge of which has been treated with diamond dust.

2. Grind and polish one surface of the specimen, and flood with a thin solution of celloidin in ether-alcohol. A solution made by dissolving 1 gm. of a standard commercial celloidin in a solution of 50 cc. of ether and 50 cc. of 100 per cent alcohol is satisfactory. Probably a solution of cellulose acetate in amyl acetate as used by WALTON[2] would serve as well.

3. Allow the solution to dry thoroughly on the surface of the rock. The evaporation of the ether-alcohol will leave a thin film of celloidin closely adhering to the polished surface of the specimen. If this film wrinkles and loosens, the solution used is not sufficiently dilute and additional ether-alcohol should be added.

4. Mount the specimen in Canada balsam on a glass slide preparatory to grinding thin with abrasive powder. Natural Canada balsam which has been heated over a water bath until it is perfectly hard when cooled has been found to be more satisfactory than Canada balsam which has been dissolved in xylol. In mounting the specimen in balsam, the surface covered with the celloidin film is placed next to the slide (fig. 1).

[1] LANG, W. H., A cellulose film transfer method in the study of fossil plants. Ann. Botany **40**: 710. 1926.

[2] WALTON, J., Recent developments in palaeobotanical technique. Congrès Stratigraphie Carbonifère. Heerlen. 1927 (1928).

5. Grind the exposed surface of the rock with abrasive powder until the section is sufficiently thin, wash and polish to remove all traces of the abrasive, and dry the section thoroughly.

6. Place the glass slide with the thin section in a shallow pan and cover with xylol. Place the pan on a warming table and warm until the balsam in which the rock has been mounted is dissolved sufficiently to loosen the section from the glass slide. Final traces of abrasive powder may be removed. Allow sufficient time for this step. Mechanical assistance in loosening the section will cause frequent disasters. Normally the presence of the celloidin film will prevent the section from breaking and will allow the following necessary steps.

7. After the section has been loosened from the slide, drain off all excess xylol, and while still on the warming table cover with a generous amount of a very dilute solution of Canada balsam in xylol. The balsam will flow

FIG. 1.—Diagram showing rock section (*a*) with celloidin film (*b*), mounted in Canada balsam (*c*) on glass slide (*d*), ready to be ground thin and polished.

quickly under the rock section, separating it from the glass slide and allowing the section to be moved with ease. Now place over the section a cover slip of the kind desired in the permanent mount. This will act as a guide in the actual transfer to the second slide.

8. The transfer is made to a warm glass slide on which has been placed a small amount of Canada balsam. Hold the slide carrying the rock section and cover slip in a vertical position above the second glass plate and allow the section, guided by the cover slip, to slide from the one to the other. Arrange the section and cover slip as desired and place in drying oven until the balsam is sufficiently hard to insure safe handling.

If the rock material is especially friable, an added precaution against its breaking during the transfer may be taken. After the rock section has been ground sufficiently thin and the abrasive powder removed, cover the exposed surface with the celloidin solution, allow it to dry, and then proceed as indicated. The celloidin clears perfectly in xylol, and its presence in the permanent mount, even covering both surfaces of the thin section, does not in the least hinder microscopical observation of sections of petrifactions.—J. H. HOSKINS, *University of Cincinnati, Cincinnati, Ohio.*

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CHROMOSOME NUMBERS IN THE CUCURBITACEAE

The chromosome counts of species of Cucurbitaceae recorded in the literature at the present time represent principally the species and varieties of economic importance. During the last two years I have been interested in making a collection of the wild and cultivated species of the family occurring in the temperate zone, and a study of the chromosome

TABLE I

Spp.	n	2n	Reported by
Bryonia alba	10	.....	von Boenicke,[1] Meurman
B. dioica	10	.....	Strasburger, Meurman
Benincasa hispida	.....	24	Author
Bryonopsis laciniosa	.....	24	Author
Citrullus vulgaris	11	.....	Kozhukhow, Author
Coccinia hirtella	.....	24	Author
Cucumis sativus	7	.....	Kozhukhow
C. melo	12	.....	Kozhukhow, Author
C. dipsaceus	.....	24	Author
C. metuliferus	.....	24	Author
C. myriocarpus	.....	24	Author
Cucurbita ficifolia	.....	42	Author
C. foetidissima	.....	42	Author
C. palmata	.....	42	Author
C. pepo	12	.....	Lundegårdh
C. pepo var. pomiformis	20	.....	Kozhukhow
C. pepo var. citrullina	21	.....	Kozhukhow
C. moschata	24	.....	Kozhukhow
C. maxima	24	.....	Kozhukhow
C. maxima	20	.....	Castetter
Cyclanthera pedata	.....	32	Author
Ecballium elaterium	.....	24	Author
Echinocystis (micrampelis) lobata	16	.....	Kirkwood
Lagenaria vulgaris	.....	24	Author
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L. marylandica	.....	26	Author
Melothria punctata	.....	24	Author
Mormordica charantia	.....	22	Author
Sicyos angulata	.....	24	Author

[1] See literature cited at end of paper for references.

number and morphology of these forms is being carried on with a view to contributing more fully to our knowledge of this family. The list of species being studied is by no means complete, but representatives from practically all genera of the temperate zone are included. It is hoped to secure knowledge of the range of chromosome number in the family as a working basis for further determinations of particular genera and species.

The work being conducted at the University of California on the Cucurbitaceae is concerned chiefly with two problems: (1) a survey of

chromosome numbers in species not heretofore studied; and (2) a cytological study of the varieties of cultivated Cucurbitaceae as a basis for the interpretation of results of breeding experiments now being carried on.

Table I gives a complete summary of the reported chromosome numbers in the Cucurbitaceae.

It will be noticed that there is a lack of agreement in the numbers reported by various investigators for the species and varieties of the genus *Cucurbita*. The purpose of the present work is also to take up a thorough treatment of the somatic chromosomes of the species and varieties of this important genus, in an effort to determine whether or not there is a range of variation of chromosome numbers as suggested by these earlier results. The somatic chromosomes are being studied in root cells, and in most cases the haploid number will be determined from pollen mother cells as a check against the somatic count.—J. W. McKay, *University of California, Berkeley, Calif.*

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CURRENT LITERATURE

BOOK REVIEWS

Outlines of biochemistry

There has been great need of a good text on biochemistry for the student of the non-medical biological sciences. An attempt to meet this need has been made by GORTNER,[1] who has brought into book form the experiences of years of research and teaching in the division of agricultural biochemistry of the University of Minnesota.

The seven sections of the text present (a) the colloid state of matter; (b) proteins; (c) carbohydrates and allied compounds; (d) tannins; (e) plant pigments; (f) fats, lipides and essential oils; (g) biocatalysts. The first of these sections consists of ten chapters on colloidal phenomena. This is one of GORTNER'S favorite fields, and it is handled in characteristic fashion. It is an indication of the importance which the author attaches to these colloidal relations, that more than a third of the space of the entire volume is devoted to them. It is on the whole an attractive and stimulating summary of the physics and chemistry of matter in colloidal subdivision.

The section on proteins consists of ten chapters also, and occupies about one-fourth of the volume. The scope of treatment is indicated by the following abbreviated chapter headings: amino acids; polypeptides; analysis; structure and isomerism; classification; properties of protein systems; reactions with acids and bases; metabolism; biological reactions; and nitrogen bases.

The carbohydrates and their congeners are treated less extensively, but with sufficient detail as to the chemistry of the group. The first chapter in this section discusses the problems of optical rotation, isomerism, the importance of the carbohydrates, synthesis of carbohydrates in nature, the first sugar formed in the process of photosynthesis, the energy relations of photosynthesis, and the classification of the carbohydrates.

To the reviewer the book seems better fitted to the needs of students of zoology, botany, agriculture and its related biological fields than any text on biochemistry hitherto produced. Much of the text has previously been given in the form of class lectures, and the author and publishers deserve the thanks of students of biology for presenting the material in permanent form.—C. A. SHULL.

Hydrogen-ion concentration in plant cells and tissues

The second volume of this series[2] is a monograph on hydrogen-ion concentration with special reference to plant materials, by SMALL, who has been a student

[1] GORTNER, R. A., Outlines of biochemistry. 8vo. pp. xvi+793. New York: John Wiley and Sons. 1929.

[2] SMALL, J., Hydrogen-ion concentration in plant cells and tissues. Protoplasma Monographien Vol. II. 8vo. pp. xii+421. Berlin: Gebrüder Borntraeger. 1929.

in this field for a number of years. The work is divided into three sections, the introduction, methods, and results. The introduction considers the hydrogen-ion concentration problems in connection with stability of the proteins, their characteristic reactions, and the effects of variations of pH upon the living and reserve proteins; enzyme action; the buffer systems in cells; variations in pH of sap, wall, and protoplasm, etc.

Part II on methods contains eight chapters, with discussions of the hydrogen electrode measurements, quinhydrone, and micro-hydrogen electrodes; comparator indicator methods, capillator indicator, special indicator methods, range indicator methods, and buffer determinations.

The results are recorded first in the form of a general survey of tissue reactions, and diurnal and seasonal changes in reaction; then such special cases as follows: the sunflower, broad bean, potato, succulents, etc. The final chapters are devoted to the relations of protoplast, cell sap, and cell walls to pH, buffers and buffer indexes in plants, and a restatement of the problems at the close. There are several appendixes, on Embden's phosphate method, organic acid analysis, and supplementary references. The literature citations occupy 25 pages, and provide an excellent guide to the past literature of the subject.

The book is full of information, and will be found useful especially by students who have to supplement inadequate chemical background by recourse to books upon the subject of hydrogen-ion measurements. The reviewer notes the criticisms of some American work in various places through the volume. After all, there is nothing sacred about the way in which we present our ideas. A certain amount of standardization in presentation is a good thing, but it does not need to be made a fetish.

Anyone who wishes to carry on investigations in this field should have mastered the material presented in such a book before he begins.—C. A. SHULL.

General botany

In the second edition of HOLMAN and ROBBINS' well known and widely used textbook of general botany,[1] published in the fall of 1927, the organization and method of treatment of the subject are essentially the same as in the first edition, which was published in 1924, and reviewed in the March, 1925, issue of this journal.

The principal changes in the second edition are: the introduction into the first and second chapters of brief statements of certain physical and chemical principles with which the student should be acquainted in order to understand the fundamentals of plant physiology; placing of the chapter on the plant body before the chapter on the cell instead of after it, as it was in the first edition; the introduction at the end of Part I of a chapter on the relation of the plant to its environment in place of the "summary" chapter of the first edition; the

[1] HOLMAN, R. M., and ROBBINS, W. W., A textbook of general botany. 8vo. pp. xiii+624. *figs. 415.* New York: John Wiley & Sons. 1927. $4.

introduction in the chapter on the spermatophyta of an account of the principal tendencies in the evolution of the angiosperms, based upon CLEMENT'S presentation of the Besseyan system; various changes throughout the text prompted by recent advances in botanical knowledge, particularly in histology and physiology; the addition of more than fifty new illustrations and the redrawing, entirely or in part, of about the same number of figures used in the first edition.

The second edition, like the first, is written in clear style, including much detail, and is amply illustrated.—J. M. BEAL.

Canary Islands plants

The Canary Islands have long had a special fascination for botanists because of their position, abundant endemics, and the close affinity of their flora to that of Tertiary times. In spite of this attraction their flora has been rather imperfectly known. The present monograph,[1] however, will do much to advance our knowledge of this remarkable vegetation.

The age and climate of the islands are examined and the influence of climate on the vegetation considered. There follows a description of the vegetation of seven individual islands. Then comes the major portion of the volume in the special investigations of the author on the various species. Each species is carefully considered and its peculiarities described. These descriptions, together with remarkably fine plates from photographs by the author, make a detailed knowledge possible. It is a valuable study presented in most attractive form.—G. D. FULLER.

Tropisms

This volume[2] is one of a series of monographs reviewing and bringing to date various branches of science. The first part of the book summarizes what is known of tropisms in both plants and animals, and there is an extensive bibliography at the end of each of the six chapters. The bibliography of phototropism of plants occupies ten pages and contains some 150 citations. The second part of the volume is concerned with a critical examination of the theories of JENNINGS and of LOEB; while the third part contains a general discussion of transmission of stimuli and its relation to philosophy and psychology.

Such a useful work of reference deserves to be better printed and more attractively bound.—G. D. FULLER.

The one-year course in general biology

An impressive text for a first-year college course in general biology has been prepared by PLUNKETT.[3] In temporary form, this book has already received a

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[1] BURCHARD, OSCAR, Beiträge zur Ökologie und Biologie der Kanarenpflanzen. Bibliotheca Botanica. Edited by L. DIELS. 4vo. Heft **98**: pp. *262. pls. 86, map.* Stuttgart. 1929.

[2] ROSE, MAURICE, La question des tropismes. Les problèmes biologiques. XIII. pp. vii+469. *figs. 90.* Paris: Les Presses Universitaires de France. 1929. 15 fr.

[3] PLUNKETT, C. R., Outlines of modern biology. 8 vo. pp. vii+711. *figs. 198.* New York: Henry Holt & Co. 1930. $3.75.

five-year trial with classes of over a thousand students each at New York University. The basis of organization is the concept of the living organism as a physico-chemical mechanism. Accordingly the twenty-seven chapters are grouped into five sections: I. protoplasm; II. nutrition; III. response; IV. reproduction; V. evolution. Illustrations are chosen freely from plants, lower animals, and man, phylogenetic considerations being reserved for the last few chapters. An index and a short list of selected references appear at the end.

Admittedly the contents are rather full for an eight-months' college course, and perhaps a little more difficult than is customary in biology. Deliberately the student is exposed to more than he is expected to reproduce in examination. Yet there are elements of flexibility which should enable each teacher to use as much or as little of the contents as are appropriate for his own group. Although the text does not commit the teacher to any one style of laboratory program, an accompanying laboratory manual by H. J. FRY is promised shortly.

In this day of survey courses this book should undoubtedly find a place. It is more highly synthetic and more dominantly physiological than any other first-year biology the reviewer has seen.

Almost simultaneously there appears a revised edition of a similar volume by SCOTT.[1] This represents the more orthodox handling of first-year college biology. The first half of the book contains a detailed and systematic treatment of plant and animal phylogeny, while the last half is organized into: the cell; embryology; histology; comparative anatomy; reproduction; physiology; genetics; distribution of organisms in time and space; evolution; the biology of man. A comprehensive glossary and index are included, while a generous list of selected references appears at the end of each chapter.—M. C. COULTER.

Phylogeny of plants

A volume[2] with a pretentious title has just appeared, and any presentation of it by one man is sure to be stronger in the field of that man's research. Outside of that field he must rely largely upon literature. The conclusions in any treatment of phylogeny are based upon paleobotany, experiment, and comparative morphology. The law of irreversibility, which has been established principally by vertebrate paleontologists, is well stated.

The first part of the book deals with the morphology of plants, from the Cyanophyceae to the orchids. Some of it is well presented, especially the morphology of fossil plants; but in the life history diagrams there are some surprising inaccuracies. The tetraspores of *Dictyota* are motile and the sperm has two cilia. The egg of *Laminaria* is figured with cilia. Investigations here are none too complete, but the behavior shows that this egg is of the non-motile type. The sperm is figured with two cilia, which is probably correct; but, so far

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[1] SCOTT, G. G., The science of biology: an introductory study. 2d ed. 8vo. pp. xx+633. *figs.* 390. New York: Thomas Y. Crowell Co. 1930. $3.75.

[2] ZIMMERMAN, W., Die Phylogenie der Pflanzen, ein Überblick über Tatsachen und Probleme. 8vo. pp. xi+452. *figs.* 250. Jena: Gustav Fischer. 1930.

as the reviewer knows, cilia have not yet been discovered. The egg of *Fucus* is shown with two cilia. The author's knowledge of life histories should be more accurate, if he is to draw important conclusions from them.

In looking through the numerous illustrations, it is evident that many are incorrectly acknowledged. Some, which the reviewer did not make, are credited to COULTER and me; and a number of my illustrations of gymnosperms are credited to another author; some of RENAULT'S figures are credited to ARBER, etc. The author evidently merely consulted general accounts, in which the illustrations may have been properly acknowledged, and carelessly credited that source instead of the original account. Unfortunately the present book is not the only offender of this sort.

Some conclusions, as expressed in diagrams, may be mentioned: the Flagellates have given rise to the fungi; then in succession to the red, brown, and green algae, with the possibility that some of the fungi may have come from the red and green algae. The Cyanophyceae, which are referred to as having no nuclei ("Kernlose Thallophyten"), are a parallel development and have given rise to the bacteria. The Pteridospermae, Cordaitales, and Coniferae are derived from the Filices; but there is a suggestion that the Coniferae may have come from the Lycopsida. Both Ginkgoales and Cycadales are derived from the Pteridospermae; and the Cycadales have given rise, in the Triassic, to both the Bennettitales and angiosperms. The Gnetales are derived from the Bennettitales.

Until much more is known about development, and especially the amount of reliance which can be placed upon similarity of structures in determining relationships, any phylogenies will be tentative. The subject is advancing and the present book makes some contribution, especially where it touches upon paleobotany, ancient geographic distribution, and the principles of phylogeny.—C. J. CHAMBERLAIN.

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